

# Application of Artificial Intelligence to Automatically Verify Student Calculations in Higher Education Institutions

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**Abstract**— Artificial Intelligence (AI) is becoming a key tool in education, automating the verification of students' calculations, which is especially important for disciplines involving mathematical and technical calculations. The article focuses on improving the digital literacy of students and teachers through the integration of innovative technologies. The use of AI transforms learning by promoting individualization of the process, instant feedback and in-depth mastering of the material. The perspectives of adaptive educational platforms that analyze the level of preparation of students and build personalized learning trajectories are discussed. The challenges of AI implementation are also discussed, including algorithm improvement, ethical issues of automated assessment, and integration with existing educational systems. The study evaluated the effectiveness of implementing AI systems to check students' calculation papers. The results showed that the use of artificial intelligence allowed to reduce the time of work verification by 60-70%, to increase the accuracy of assessment by 25-30% due to minimization of the human factor, and to increase student performance by 15-20% due to individualized recommendations. It is concluded that the use of artificial intelligence in the verification of calculations not only increases the efficiency of the educational process, but also develops students' skills in working with digital

technologies, which are necessary in modern conditions. The introduction of artificial intelligence into the educational environment contributes to the creation of adaptive, interactive and innovative approaches to learning, improving the quality of education and its accessibility.

**Keywords**— artificial intelligence, check automation, higher education, pedagogical experiment.

## I. INTRODUCTION

In today's world, global digitalization has had a significant impact on all aspects of human life, including education. The use of information technologies is becoming an integral component of the educational process, contributing to its efficiency. One of the key directions of digitalization of education is the integration of artificial intelligence (AI) to automate various processes, in particular, the verification of calculation works of applicants for higher education.

The relevance of this study is due to the need to adapt the educational system to the requirements of the digital age. With the growing number of applicants for higher education and the volume of educational materials, traditional methods of checking student papers are

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becoming less effective. The integration of artificial intelligence allows solving a number of problems, such as limited time of teachers, subjectivity of assessment and the need for quick feedback. It is especially important to implement such technologies in developing countries, including Ukraine, where educational institutions face the challenges of optimizing processes in the context of limited resources.

The rapid development of artificial intelligence technologies creates a need to study their impact on the educational process. This includes assessing how effective such solutions are in improving the quality of learning, as well as finding the best ways to integrate them into the educational environment.

In November 2023, the Organization for Economic Cooperation and Development updated its definition of AI, noting that “an artificial intelligence system is a machine system that, in order to achieve explicit or implicit goals, makes inferences from the input data it receives about how to generate inputs such as predictions, content, recommendations, or decisions that can affect the physical or virtual environment” [1].

In recent years, researchers have been actively exploring the implementation of AI in educational environments, analyzing its effectiveness, benefits and challenges. Scientists offer different approaches to the use of AI in education, considering both technological and pedagogical aspects of this process.

Norbert Annus [2] explores the impact of intelligent educational software on the learning process. Based on international research, he presents 15 educational software solutions that, thanks to their intelligent features, accelerate and simplify the learning process, supporting differentiated and more personalized learning.

In [3], the researchers review the application of machine learning algorithms to automatically grade student papers. They provide practical recommendations for the selection and implementation of such algorithms in educational environments, analyzing their efficiency and accuracy. The main focus is on algorithms that can improve the objectivity and speed of assessment, reducing the burden on teachers. The works [4] – [6] describe modern approaches and technologies of artificial intelligence application in higher education, data mining methods that can be used to assess and predict students' academic performance, which allows to identify patterns in academic achievements, identify potential risks of falling behind and adapt the educational process to individual student needs. The authors Chen L., Chen P., Lin Z [7] discuss the challenges associated with the introduction of AI in education, such as ethical issues, the need to train teachers to work with new technologies, and ensuring equal access to innovation for all participants in the educational process.

A wide range of issues, also technical aspects of AI implementation, analyzing both opportunities and challenges arising from the integration of digital technologies in engineering is shown in Crawford, K. [8].

The work of [9] is devoted to the use of AI in the educational process of training specialists to work in the conditions of digital transformation of production, considering the issues of integration of innovative digital tools in engineering training and production. Roll, I., & Wylie, R consider the possibilities of personalized learning and optimization of teaching methods [10].

Ukrainian scientists are also actively studying different aspects of the implementation of artificial intelligence systems in the educational sphere, considering their opportunities, challenges and prospects. Among the leading researchers of this topic we can mention [11] – [14]. and others. The results of their work contribute to the expansion of opportunities for the use of AI in domestic education, the formation of modern approaches to the digital transformation of the educational process and the development of strategies for the effective implementation of the latest technologies.

In general, artificial intelligence, according to these definitions and descriptions, covers the development of machines that have a certain level of intelligence and are capable of performing human-like functions, in particular cognitive, learning, decision-making and adaptation to the environment. In the educational environment, AI facilitates the automation of routine tasks, personalization of the learning process, adaptive learning and improved assessment of students' knowledge. At the same time, the issue of the effectiveness of AI systems in the verification of computational works, in particular, regarding the correctness of the interpretation of physical formulas, the logic of solution execution and compliance with methodological requirements, remains insufficiently investigated. The purpose of this study is to analyze the theoretical and practical aspects of the application of artificial intelligence in the educational process, to assess its impact on the effectiveness of learning, as well as to consider the ethical, social and technical aspects of the integration of artificial intelligence in educational institutions, which will make it possible to formulate recommendations for its effective implementation and use.

## II. MATERIALS AND METHODS

Modern educational process needs innovative approaches to the verification of calculation tasks in exact sciences, particularly in physics. In order to train engineers at the master's level to familiarize them with modern developments, teaching tasks are formed on the basis of modern scientific works [15; 16], which contributes to a faster integration of a specialist into the production environment. Traditional methods of assessment require a lot of time and effort of teachers. The introduction of artificial intelligence into this process allows to automate verification, improve the accuracy of assessment and provide students with quick feedback. At the same time, the issue of the effectiveness of artificial intelligence systems in the verification of calculation works, in particular, regarding the correct interpretation of physical formulas, the logic of solution execution and compliance with

methodological requirements, remains insufficiently researched.

The methodology of artificial intelligence application for automated physics examinations is based on algorithms of machine learning, symbolic mathematics and natural language processing. It is aimed at analyzing students' decisions, identifying errors and providing detailed feedback, which allows to significantly increase the objectivity of the check and accelerate the educational process.

The methodology also involves integrating the system with educational platforms such as Moodle, Google Classroom and Microsoft Teams, which allows automating the verification process, tracking student performance and generating progress reports. Teachers can customize the validation parameters, setting the level of assessment rigor, while students get immediate access to the results and recommendations on how to improve their skills.

Moodle is one of the most popular LMSs, offering flexibility through a system of plug-ins and integration with external tools. For automated checking of calculations, Moodle uses the STACK plugin, which allows you to analyze mathematical and physical expressions taking into account symbolic transformations. It connects Maxima CAS (Computer Algebra System), which allows you to automatically evaluate numerical and algebraic answers by comparing them with reference solutions. Additionally, Python libraries (SymPy, NumPy) can be integrated, creating custom plugins to analyze students' solutions, and OCR tools (Tesseract, MyScript) can be used to process handwritten formulas and equations. Another approach is to use Google Colab and API, where calculation files are uploaded for automatic validation and TensorFlow/PyTorch-based neural network models analyze typical student errors to help tailor feedback.

At the verification stage, the system divides the solution into key elements: initial data, applied formulas, sequence of calculations and final result. The analysis includes verification of correctness of numerical calculations, equivalence of mathematical expressions, correct use of physical laws and observance of dimensions. The use of symbolic mathematics methods makes it possible to determine whether the presented expressions are equivalent to the reference solution, even if the student used a different calculation method. An important part of the methodology is the identification of typical errors. The system analyses inaccuracies, including arithmetic errors, incorrect choice of formula, incorrect application of physical laws, and incorrect rounding. It also evaluates the logical structure of the solution: sequence of actions, correctness of intermediate calculations and correctness of using units of measurement. After analysis, the system generates feedback, providing the student with a detailed analysis of errors and an explanation of the correct solution method. Depending on the complexity of the task and the student's level of preparation, personalized learning adjustments are possible: recommendations for additional materials, analysis of similar examples, and individual assignments to

eliminate gaps in knowledge. Machine learning methods are used to improve the accuracy of verification, which allows analyzing a large database of student solutions and identifying common errors. Natural language processing technologies are used to analyze explanatory texts, and neural network models help recognize handwritten mathematical expressions. This makes verification as accurate as possible and adaptable to different problem-solving styles.

### III. RESULTS AND DISCUSSION

It was decided to conduct research on the effectiveness of using artificial intelligence for automated verification of calculation papers in physics among applicants for higher education specialty 208 “Agroengineering” of the institution of higher education “Podolsk State University”, as well as to assess the accuracy of verification, the ability to detect errors and the quality of the provided feedback.

The procedure of the experiment implies several main stages. The stages of the experiment are reflected in Table 1.

TABLE 1 STAGES OF THE EXPERIMENT

| Stage                               | Description   |
|-------------------------------------|---|
| Preparation of the AI system        | Formulation of evaluation criteria and setting up algorithms for recognizing physical expressions.        |
| Selection of participants           | Distribution of students into experimental and control groups.  |
| Task execution                      | Solution of identical calculation works by both groups.   |
| Work verification                   | Evaluation of works: in the control group – by the teacher, in the experimental group – by the AI-system. |
| Comparing results                   | Analysis of differences in the grades, accuracy of error detection and efficiency of evaluation.          |
| Analyzing participants' perceptions | Discussion with teachers and students on the quality of the automated check and its possible application. |

The first step is the preparation of the AI-system, including the formulation of evaluation criteria and setting up algorithms for recognizing physical expressions. Next, the selection of participants is made, in which the students are divided into two groups: experimental and control. The next stage is task performance, where both groups solve the same computational work. After that, the works are checked, and in the control group the evaluation is carried out by the teacher, and in the experimental group – by the AI system. An example of a calculation work is shown in Fig. 1.

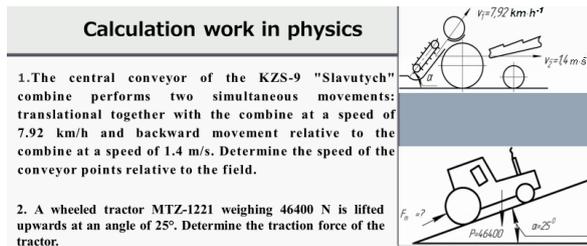


Fig. 1. Tasks for calculation work in physics for students of the specialty “Agroengineering”.

The final step is to analyse the participants' perceptions, involving discussion with instructors and students about the quality of the automated checking and its potential for integration into the teaching process.

During the automated verification of this calculation work by artificial intelligence, various errors related to the processing of numerical data, interpretation of physical quantities and correct application of formulas were detected.

In the first task, where the movement of the central conveyor of the KZS-9 “Slavutich” combine harvester is considered, errors were found in calculations of the total velocity of the conveyor point relative to the ground. The artificial intelligence incorrectly took into account the directions of motion and misinterpreted the units of measurement, because the speed is given in different systems (kilometers per hour and meters per second). The students used different calculation methods (vector addition and scalar approach), which led to differences in the format of the answer record, which the system perceived as incorrect.

In the second task, concerning the determination of the tractive force of the MTZ-1221 tractor when driving at an angle of 25°, there were difficulties in recognizing the physical components of the force. Artificial intelligence failed to take into account differences in the use of trigonometric functions (e.g., sine or cosine of an angle) depending on the chosen solution method. Errors were also found in the correctness of recognizing the force of gravity and its decomposition into components, as different students used alternative forms of writing equations, the results improved if the students were pre-trained and fluent in the method of analyzing and investigating the motion of energy vehicles [17].

In addition, the automated checking system misinterprets the rounding of numbers, resulting in a student's answer containing minor deviations from the expected value being labeled as incorrect. Difficulties were also found in processing graphical elements or explanations if the student supplemented the calculations with diagrams or explanations in a non-standard format. Thus, automated checking of such calculation papers has some limitations that may affect the accuracy of the assessment. In order to reduce the number of erroneous rejections of correct answers, it is necessary to improve algorithms for recognizing physical equations, to ensure adaptability to different solution methods, and to improve mechanisms for

analyzing graphical materials in students' answers. At the final stage, statistical analysis was carried out, which involved processing the obtained results, determining the mean values of the scores, analyzing the deviations, and evaluating the differences between the two methods of verification. The results of the validation are shown in Fig. 2.

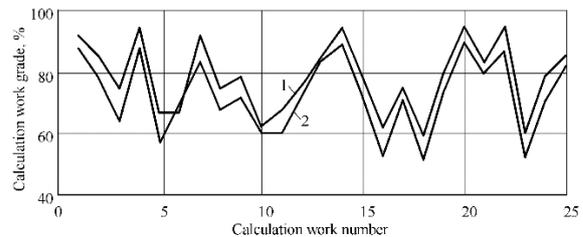


Figure 2. Results of the test: 1 – experimental group; 2 – control group.

The analysis showed that, although automated verification provides a significant acceleration of the evaluation process, it has certain limitations in cases where student solutions differ from the template solutions but remain correct. In particular, in the control group, where teachers performed the verification, the percentage of erroneously low marks was lower, which is explained by the teacher's ability to analyze the logic of the student's solution, not only the final result. At the same time, in the experimental group, where the AI performed the verification, a more rigorous assessment was observed, as the system was oriented to predetermined answer patterns. This confirms the need for further improvement of automated assessment algorithms to take into account different physical approaches to problem solving.

Table 2 displays the distribution of students' performance levels in the control and experimental groups after validation. In the experimental group, the assessment was carried out by artificial intelligence, while in the control group the verification was carried out by teachers. The comparison of the obtained results allows us to assess the impact of automated testing on the level of material assimilation and assessment accuracy.

TABLE 2 RESULTS OF THE INSPECTION

| Levels     | Experimental group | Control group |
|------------|--------------------|---------------|
| Elementary | 12%                | 9%            |
| Medium     | 44%                | 27%           |
| Sufficient | 25%                | 42%           |
| High       | 19%                | 22%           |

The results of the verification showed that the use of artificial intelligence for automated assessment of calculation works has an impact on the distribution of students' performance levels. In particular, in the experimental group, where the verification was performed with the help of AI, there is an increase in the proportion of students with an initial level (12%) compared to the control

group (9%). There is also a decrease in the number of students with sufficient level in the experimental group (25%) compared to the control group (42%), which may indicate a more accurate and rigorous AI approach to assessment. In addition, the proportion of students with a high level in the control group (22%) is higher than in the experimental group (19%), which may be due to certain limitations of AI algorithms in accounting for creative or non-standard solution methods.

A survey of students who participated in the experiment showed that 78% of the respondents positively evaluated the automated check and noted that the quick feedback helped them better understand their mistakes. At the same time, 22% of students indicated that the automated assessment was sometimes too harsh or unfair, especially in cases where they used non-standard solution methods. Some students expressed concern that the AI was not always able to evaluate the logic of a solution in the same way that an instructor does. They noted the need to refine the evaluation algorithms to accommodate different approaches to task completion.

#### IV. CONCLUSION

The results of the study confirm that the use of artificial intelligence for automated verification of physics calculations significantly increases the objectivity of evaluation, reduces the verification time and improves the quality of the educational process. In contrast to traditional methods based on manual checking by a teacher or simple automated systems, the proposed approach includes complex analysis of solutions taking into account the logic of calculations, application of physical laws and observance of dimensions.

Our research differs from other works in the field of automated checking of calculations in the fact that it offers a comprehensive and adaptive approach that takes into account not only the correctness of the final result, but also the entire logic of problem solving. Unlike traditional systems focused on template comparison with a reference answer, our methodology analyzes intermediate calculations, logical sequence of actions, and correctness of the use of physical laws.

Thus, our study not only confirms the effectiveness of using AI in educational processes, but also proposes an innovative method for checking computational work that combines intelligent decision analysis, personalized feedback, and adaptive scoring system, making it more flexible and accurate than existing approaches.

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