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ARTIFICIAL INTELLIGENCE AS A TOOL FOR PEDAGOGICAL INNOVATIONS IN MATHEMATICS EDUCATION

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Abstract. This article examines the emerging role of artificial intelligence (AI) tools in school education, highlighting the opportunities, benefits, and challenges they present for teaching and learning. It focuses on generative AI technologies – such as large language models, visual content generators, and educational chatbots – that are increasingly assisting teachers in preparing and delivering mathematics instruction. Special attention is paid to platforms that enable the automated generation of specific learning resources, such as digital worksheets and flashcards. The discussion is based on examples from the curriculum in probability and statistics, which demonstrate how effectively resources can be created using artificial intelligence. In addition, the article addresses issues related to data privacy, the reliability of content created with artificial intelligence, and the need for pedagogical monitoring to ensure the responsible and effective integration of artificial intelligence in the classroom.

Keywords: artificial intelligence; large language models; flashcards; worksheets; interactive diagrams; chatbots.

1. Introduction

In recent years, Artificial Intelligence (AI) has experienced rapid development, transforming from a predominantly experimental field into a ubiquitous technological force with concrete applications in everyday life. Driven by breakthroughs in cloud computing, the widespread adoption of large language models, and advances in machine learning algorithms, AI has led to the creation of a diverse and expanding ecosystem of tools. These developments have opened new opportunities for the meaningful integration

of AI into the educational context, improving both teaching and learning processes.

More popular and accessible technologies with wide application in education include the following:

– Large language models (e.g., ChatGPT, Gemini, Claude), which can generate original content, including texts, lesson plans, tests, course assignments, and more (Gurl et al., 2025; Attard & Dingli, 2024);

– Generative image tools (such as DALL·E, Midjourney, Leonardo.ai, Canva AI), which generate images based on text prompts and are suitable for creating illustrations, infographics, posters, and other visual educational resources (Reed, 2023; Hwang & Wu, 2025);

– Video and animation generation tools (e.g., Pika Art, Hailuo AI, Animaker), which support the creation of short video lessons or animated presentations (Contreras et al., 2024; Leiker et al., 2023);

– AI audio platforms (e.g., ElevenLabs, Murf.ai, Suno) – used for generating dictations, educational songs, audio stories, and voiceovers for videos (Jadhav et al., 2024; Morales-Chan et al., 2024);

– Virtual educational assistants created using tools such as Poe, Character.AI, or Custom GPTs, which support students in their independent work (Sajja et al., 2023; De-La-Cruz-Vasquez et al., 2024).

The availability of such a wide range of digital technologies allows teachers to optimize teaching effectiveness, use innovative pedagogical approaches, and adapt the learning process to meet the diverse and changing needs of their students, thereby promoting deeper engagement and metacognitive habits that are essential for long-term learning. In this article, the term "pedagogical innovation" refers mainly to the introduction of new methodological approaches in mathematics education enabled by AI tools, such as the creation of interactive resources, adaptive formative assessment, and personalized learning activities.

Mathematics education in schools is associated with a number of challenges that affect both students and teachers. The abstract nature of concepts such as "probability", "function" and "distribution" requires that they be explained using concrete examples and visualized in an appropriate

way. Additionally, a lack of logical thinking skills, gaps in knowledge from previous grades, and math-related anxiety further complicate the learning process. In many cases, the curriculum is overloaded with theoretical content, leaving little time for sufficient practical exercises during class. As a result, students often struggle to understand the relevance of mathematics to real life, which leads to decreased motivation. A critical issue is the lack of accessible and engaging educational resources that meet the needs of modern teaching and learning.

Artificial intelligence offers a wide range of tools and technologies for overcoming some of these challenges. With the help of generative AI tools, such as large language models and visual generators, teachers can create high-quality educational resources – worksheets, flashcards, tests, visual representations of abstract concepts, and more – much more quickly and easily. This not only reduces the workload for educators but also makes the learning process more individualized, accessible, and motivating for students. By integrating AI into the educational process, it is possible to achieve greater student engagement, deeper understanding of the material, and improved outcomes in mathematics learning.

The article presents several ideas for using AI tools in school-based mathematics education. Some of the resources were piloted at "Otets Paisiy" Primary School in Topolovo, Bulgaria, during the 2024/2025 academic year.

2. Flashcards as a pedagogical tool for enhancing active engagement in mathematics classrooms

Flashcards are educational tools that support the memorization and understanding of new terms and concepts. Typically, one side of the card contains a question, while the other side provides the answer. These cards stimulate memory and logical thinking and can be used as a tool to encourage independent learning and real-time monitoring of student understanding. Flashcards are more than just memory aids; they are active learning tools based on the practice of information retrieval.

In the early 1970s, German educator Sebastian Leitner introduced a simple, yet brilliant idea: a multiple-box system to sort flashcards by difficulty, making spaced repetition both systematic and accessible (Leitner

1974). This method, known simply as the "Leitner system" is built on decades of memory research – turning a classroom tool for memorizing languages into a method that is applicable across subjects, including mathematics. In recent years, spaced repetition software and online platforms such as Mnemosyne (mnemosyne-proj.org), Synap (synap.ac), and Duolingo (duolingo.com) have become increasingly popular, often replacing the use of physical flashcards (Tabibian et al. 2019).

Research by Rickard et al. (2008) shows that retrieval practice – actively recalling information from memory – creates stronger memory traces than passive review and improves students' ability to apply math knowledge in new contexts.

While the flashcards were first associated with language learning, the authors' educational practice has shown that flashcards – especially when paired with spaced repetition – can be highly effective in subjects like mathematics. When learners are forced to recall rules and solve problems through flashcards, especially spaced over time, they build deeper conceptual understanding. This approach is more effective than simply re-reading notes or reviewing a worksheet.

For example, the topic of probability introduces students to concepts such as likely vs. unlikely events, simple experiments (like coin tosses or dice rolls), and calculating probabilities. Although these ideas are conceptual, they rely on factual knowledge and repeated practice to build fluency. Flashcards offer a clear way to break these ideas down into manageable parts and give students the repeated exposure they need. Moreover, probability is often taught through experimentation and intuition, but it still requires familiarity with terminology, calculations, and logic. Teachers can create flashcard sets that align directly with the curriculum – ensuring accuracy, clarity, and relevance.

In mathematics education, teachers can use flashcards for:

– memorizing and reinforcing key terms;
– visualizing concepts through graphs, images, or brief descriptions;
– presenting example problems and solutions;
– checking knowledge through individual or group games;
– monitoring progress to track conceptual development;

– serving as a diagnostic tool to uncover misconceptions;
– assigning practice exercises as homework;
– promoting self-assessment and peer assessment.

2.1 Integrating digital flashcards into formative assessment practices

Table 1 highlights the pedagogical potential of electronic flashcards, especially in the context of formative assessment, which emphasizes continuous feedback, adaptation of learning, and self-regulation of learners (Black & Wiliam, 2009). The main features of these tools – such as real-time analysis, spaced repetition, and adaptive task sequencing – are closely related to the principles of formative assessment, allowing teachers to dynamically monitor learning progress and adapt instruction accordingly. In addition, digital flashcard platforms facilitate low-risk repetitive practice, allowing students to reflect on their own perceptions, receive immediate feedback, and engage more actively in the learning process (Shute, 2008; Nicol & Macfarlane-Dick, 2006). In this way, electronic flashcards serve not only as a memory aid, but also as a tool for promoting self-directed learning, which is fundamental to the development of competencies such as critical thinking, creativity, and digital content creation and editing skills.

Table 1. Electronic flashcards as a tool for formative assessment

Feature	Teacher Benefit	Student Benefit
Real-time analytics	Adjust instruction quickly	See own progress instantly
Spaced repetition engine	Prioritizes weak areas automatically	Increases retention through personalized review
Easy-to-edit flashcards	Customize to curriculum and standards	Learn in digestible, clear chunks
Open-ended response options	Access qualitative data	Practice explaining math reasoning

2.2 Creating flashcards with AI

Integrating flashcards into the learning process does not require complex preparation or technical knowledge from the teacher. There are numerous AI-powered software applications that simplify the creation of flashcards – such as Wayground, Knowt, Quizlet, and others.

Wayground[4], formerly known as Quizizz, is an AI-powered online platform well-known for its robust capabilities in creating interactive quizzes and flashcards, supporting various assessment systems. Users have access to shared banks containing thousands of ready-made tests and resources. Wayground promotes gamification through elements such as avatars, music, points, bonuses, and leaderboards. It also offers integration with other platforms like Google Classroom, Microsoft Teams, and Canvas, as well as options for exporting content in Excel and CSV formats.

The teacher can take various approaches when creating flashcards. They can manually enter a question and answer for each card, with the option to add an image. Another possibility is to import questions from an Excel file or to input text content from which the AI can generate flashcards. Teachers can also search for, adapt, and use flashcards created by other users in the Wayground community.

To create flashcards using AI, the teacher needs to formulate a prompt that specifies the key parameters. This includes, for example, the number of flashcards, target concepts, the profile or age group of learners, style, flashcard layout, and more. A sample prompt is shown in fig. 1.

Create 12 flashcards for teaching the topic "Probability and Statistics" to 6th-grade students. Include key terms and their definitions for the following concepts: set, subset, empty set, intersection, union, random event, certain event, impossible event, arithmetic mean, finite set, infinite set, element.

Use clear and simple language suitable for 6th-grade learners. Each flashcard should have the term on one side and its definition on the other. Examples for some of the cards are welcome to help students better understand the concepts.

Figure 1. Prompt for Wayground to generate flashcards with terms from the "Probability and Statistics" unit

As a result of executing this prompt, Wayground generates the specified number of flashcards. These can be edited by the teacher, downloaded in a chosen format, or shared with learners via a generated link (see fig. 2).

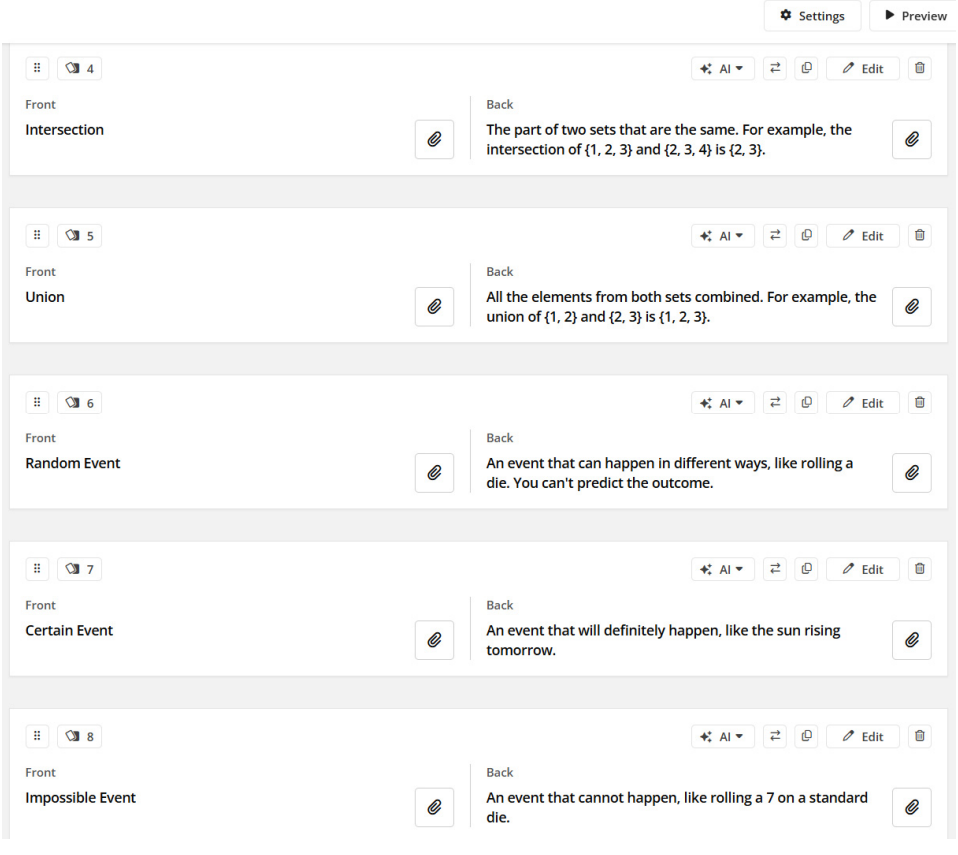

Figure 2. Flashcards generated using the Wayground application

The application includes built-in functionality that allows users to edit AI-generated content. This enables teachers to ensure accuracy and alignment with established educational practices and standards.

Similarly, flashcards can also be created using applications such as Knowt, Quizlet, and others.

3. AI-generated worksheets: reducing teacher workload and enhancing student engagement

The exercises included in a mathematics lesson are not always sufficient to ensure comprehensive understanding and memorization of the teaching material. As a result, there is often a need for additional materials that provide students with extended opportunities for practice, application, and reinforcement of the current topic. In math classes, worksheets serve as a widely used tool for this purpose, providing additional practice problems that help students acquire problem-solving skills. However, creating such resources manually, especially when tailored to different levels of student ability, can be time-consuming and labor-intensive for teachers. Recent achievements in the field of AI have greatly simplified this process by enabling the efficient creation of differentiated worksheets tailored to the curriculum. These AI-powered tools not only reduce the planning workload for teachers but also improve the personalization of the learning experience, thereby promoting active learning and keeping students engaged.

Canva[1] is an online platform that offers a wide range of tools for creating visual content. This includes various types of designs for presentations, posters, infographics, worksheets, flashcards, charts, and more. Users have access to libraries containing thousands of ready-made templates, images, icons, videos, graphics, fonts, and other. The platform supports collaborative work, integration with popular services such as Google Drive and Dropbox, as well as options for downloading and publishing resources.

Creating math worksheets with Canva is easy. The teacher simply needs to formulate a clear and accurate prompt with precise instructions. An example prompt for generating a worksheet on the lesson "Probability of a Random Event" is shown in fig. 3. The prompt specifies that the worksheet should include 10 tasks suitable for 6th-grade students, with a practical focus using various real-life scenarios, such as rolling dice, drawing cards, etc.

An essential task of the teacher is to reveal to students the connection between mathematics and other school subjects. In this way, children learn how to apply their knowledge across different scientific disciplines. Creating a worksheet for the review of the unit "Probability and Statistics" that includes tasks with cross-curricular connections is an excellent exercise for

developing higher-order thinking skills. An example prompt is presented in fig. 4. A fragment of the generated worksheet is shown in fig. 5.

Create a math worksheet with 10 exercises designed for 6th-grade students on the topic "Probability of a Random Event". The goal is to help students practice and reinforce their understanding of what probability means and how it is calculated in different real-life situations.

The worksheet should include a variety of task types: open-ended questions (where students explain or calculate), multiple-choice questions (with 3–4 options), fill-in-the-blank questions (to complete definitions or simple problems).

The exercises should be based on realistic scenarios, such as: rolling one or two dice, drawing balls from a bag with different colors, picking cards from a standard deck, choosing random items or people (e.g., names from a hat, colored marbles).

The language should be age-appropriate, and the level of difficulty should be suitable for students aged 11–12. Include a title for the worksheet, clear instructions, and space for students to write their answers.

Figure 3. Prompt to Canva for creating a worksheet for the lesson "Probability of a Random Event"

Create a math worksheet with 10 exercises designed for 6th-grade students to review the unit "Probability and Statistics". The main goal is to help students practice and reinforce their understanding of "probability of a random event" through cross-curricular connections with other school subjects.

The worksheet should include a variety of task types: open-ended questions, multiple-choice questions (3 – 4 options), fill-in-the-blank questions. It may also include tables, charts, and graphs to support data visualization and interpretation.

Each task should highlight the connection between mathematics and another subject area. Include examples such as:

– Literature: What is the probability that a student randomly chooses a specific book from the school library?
– Geography: Analyze rainfall data in different cities or calculate the probability of rain on a given day.
– Physical Education: What is the probability of a player scoring a goal from a penalty kick?
– Biology: Probability of a baby being born male or female; distribution of species in an ecosystem.
– Visual Arts: Statistical analysis of students' preferred colors in their drawings.

The language should be age-appropriate (for students aged 12 – 13). Include a title, clear instructions, and space for students to write their answers.

Figure 4. Prompt to Canva for generating a worksheet on probability and statistics incorporating interdisciplinary links

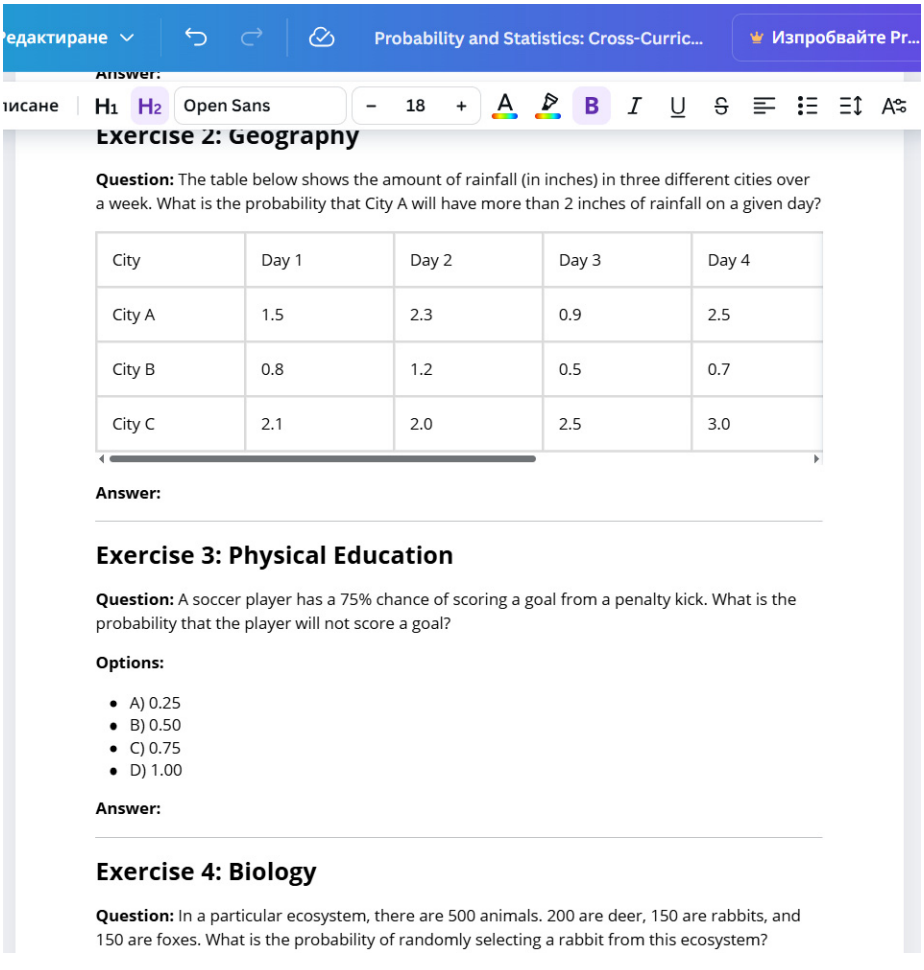

Figure 5. Worksheet with cross-curricular tasks generated using Canva

Worksheets can also be created using other applications such as Diffit, MagicSchool.ai, Eduaide.ai, and others.

4. Presenting data through interactive charts

In mathematics education, charts and graphs are frequently used. There are numerous online platforms with intuitive interfaces that are suitable for student use. One such application is ChartGo[2], which allows for quick and user-friendly creation of interactive charts. To create a chart, students need

to set several parameters, such as the title and chart type, size, axis labels, the data to be visualized, as well as display settings including styles, fonts, colors, patterns, and more (see fig. 6).

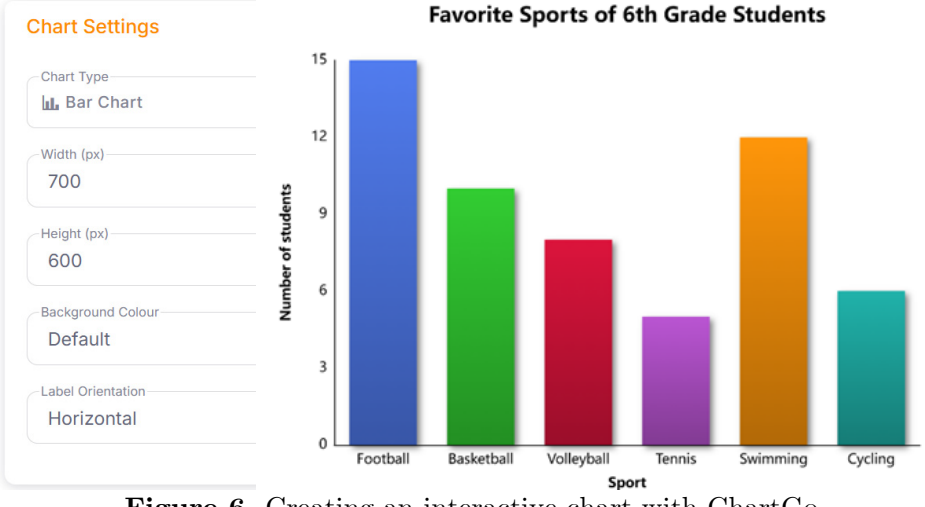

Figure 6. Creating an interactive chart with ChartGo

Students can actively participate in data analysis activities by using digital platforms to create and present charts. The teacher can organize group work by assigning students to conduct surveys and present the results. The data obtained can be visualized through statistical graphing and presented to the class for discussion and interpretation. Such teaching practices support the development of advanced cognitive skills such as analysis, critical thinking, and synthesis of information in the context of reasoned decision-making. At the same time, they contribute to the formation of digital competence and collaboration skills by engaging students in the use of modern means of online communication and coordination in a collaborative environment.

Other applications for creating charts that are suitable for student use include Meta-Chart and LiveGap Charts.

5. Supporting learning with specialized chatbots

Learners tend to maintain their attention on the educational process for a longer period when they are given the opportunity for interactive

communication. A typical example of this is chatbots powered by large language models. Using a chatbot in mathematics education can make learning more engaging and accessible for students. The chatbot can answer questions, provide examples based on real-life situations, explain new concepts in a clear and understandable way, and even offer additional practice exercises. This encourages independent work, increases student engagement, and facilitates the understanding of new topics.

In general, when creating a chatbot, the teacher must decide where the chatbot will draw its information from. There are two main approaches. In the *first approach*, the teacher prepares and provides the specific information that the chatbot will use. This may include lessons, definitions, exercises, examples, and more. In this case, the chatbot will respond solely based on the information provided by the teacher, ensuring alignment with the curriculum, the terminology being studied, and the instructional content. This minimizes the risk of the chatbot providing incorrect or inappropriate information for learners. However, the main drawback of this approach is the limited scope of the chatbot's responses.

The *second approach* assumes that the chatbot will use data it was trained on, including large amounts of publicly available information from the internet, encyclopedias, scientific articles, and other sources. This carries the risk of delivering inaccurate or unverified information. Additionally, the chatbot may use language or concepts that are not age-appropriate for the learners.

There are numerous applications that offer the ability to create specialized chatbots without the need for programming, such as Poe, Landbot, Zapier, and others.

The Poe[3] platform features an intuitive user interface and supports integration with multiple language models, including different versions of GPT, Claude, Gemini, Grok, Perplexity, and more. To create a chatbot, the user needs to configure several settings, including the bot's name and avatar, initial greeting, the model powering the bot, and others. It is also necessary to define directives that determine the chatbot's behavior, communication style, as well as other rules and limitations. Example directives are shown in fig. 7.

You are a smart and friendly educational assistant designed to help 6th-grade students learn the topic of "Probability and Statistics". Your main mission is to: answer questions on the topic clearly and accessibly; provide resources and exercises aligned with the 6th-grade curriculum; encourage students to think critically using tables, charts, and graphs; ask open-ended questions that support the development of analytical thinking. If a question is unclear, ask for clarification.

Use a friendly, encouraging, and professional tone. Speak in simple language appropriate for 12–13-year-olds. Give explanations with real-life examples and avoid complex or academic terminology. Only respond to questions related to "Probability and Statistics". If the question is outside the topic, kindly redirect the student to areas where you can help. Do not go beyond the 6th-grade curriculum. Always verify your answers based on your training, and provide only accurate and reliable information.

Figure 7. Sample directives for creating a specialized chatbot for teaching the topic "Probability and Statistics"

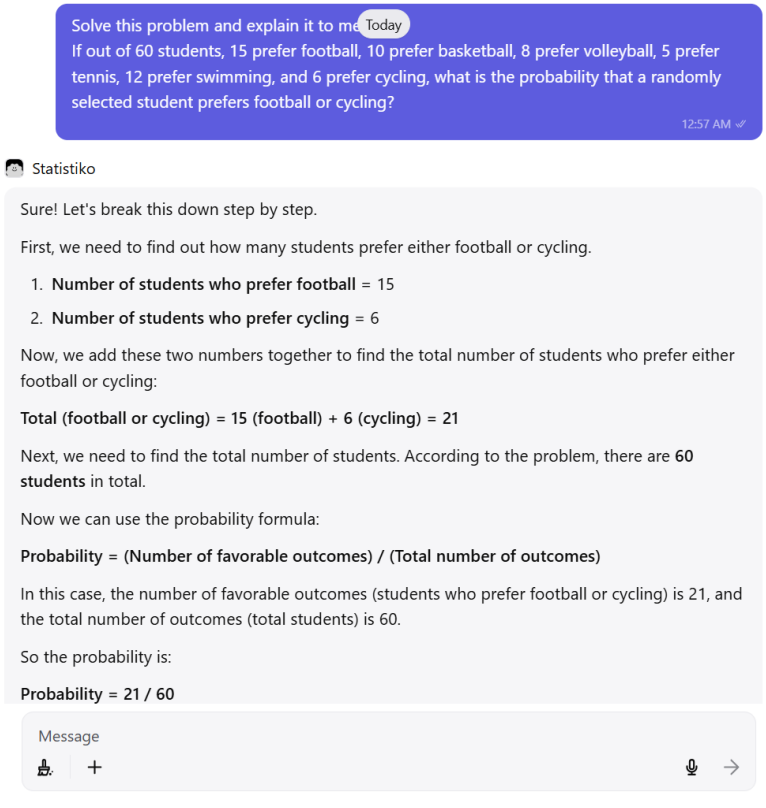

Figure 8. Screenshot from conversations with a chatbot using Poe

Fig. 8 shows screenshots from a conversation with the chatbot Statistiko, created using the directives from fig. 7. For more effective use, Poe provides the option to repeatedly edit the chatbot's settings until the desired behavior defined by the teacher is achieved.

6. Initial observations from the pilot study

The main objective of this article is to present some possibilities for using AI tools in education and their pedagogical potential. The empirical results of the study are addressed to a lesser extent.

The observations from the use of the presented tools in mathematics education (topic "Probability and Statistics") at "Otets Paisiy" Primary School in Topolovo, Bulgaria, during the 2024/2025 academic year, showed several positive effects:

– *For the teacher*: the use of AI significantly reduced the time required to prepare resources (worksheets, flashcards, and visualizations), while also facilitating their adaptation to the students' level. The teacher shared the opinion that the tools supported the application of more diverse teaching methods in class and stimulated their creativity in lesson preparation.

– *For the students*: an increased interest in mathematical tasks was observed, especially when working with digital flashcards and interactive visualizations. The students participated more actively in discussions, and some of them demonstrated improvement in understanding key concepts such as "probability" and "random event".

It is important to emphasize that these results are primarily observational and descriptive in nature and cannot be considered as a completed empirical study. In future work, we plan to conduct a more structured investigation through student surveys, as well as an analysis of achievements before and after the use of AI tools. This will allow for a more reliable assessment of their effectiveness in educational practice.

In line with the exploratory character of the pilot study, only the free versions of the demonstrated AI tools were used. The functionalities available in the free plans were sufficient to generate the educational

resources presented in this study (e.g., flashcards, worksheets, and visualizations). The platforms also offer paid subscription plans with extended capabilities, such as larger resource libraries, advanced customization options, or integration with external learning management systems. However, these additional features were not required for achieving the objectives of the pilot implementation.

7. Limitations and challenges

Creating educational resources with the help of AI comes with certain risks and challenges that teachers need to be aware of. First and foremost, *AI systems can generate content that is inaccurate or misleading*. This may confuse students and lead them to learn incorrect information (Yao 2024). Our experience from conducted experiments showed that AI-generated educational materials cannot be used directly in the teaching process due to various inaccuracies and improper phrasing. This is why teachers must always review and edit AI-generated content before using it in the classroom.

Copyright infringement is another issue that needs to be addressed. It is possible that some images, texts, or resources may be generated based on protected materials (Zhou & Rahman, 2024). One solution is to use AI tools that cite their sources or rely on licensed content.

Some platforms collect and store personal data without clear information about how it is used. This poses a risk of *violating privacy and user data protection* (Jose, 2024). For this reason, teachers should use platforms that comply with data protection standards such as GDPR and avoid entering students' personal information. If there is a need to analyze or process learning outcome data, it should be anonymized in advance.

Excessive use of AI may lead *students to lose their ability to think independently and critically* (Çela et al., 2024). This presents new challenges for teachers – how to use AI as a supportive, rather than a primary, tool, and how to develop educational resources that stimulate creative thinking.

8. Conclusion

The use of AI tools in the educational process undoubtedly offers a number of benefits. The automated creation of worksheets, tests,

presentations, and visualizations saves teachers valuable time. It becomes easy to generate content tailored to students' individual needs, including those with special educational requirements. With the help of AI, teachers can more easily create interactive and engaging materials that enhance students' motivation and active participation. This makes the learning process more effective, accessible, and aligned with the realities of today's digital world.

Alongside all its benefits, AI-driven optimization also comes with certain risks. These include the generation of educational content that is inaccurate, misleading, or inappropriate for the learners' age group; copyright infringement; and the unauthorized sharing and access to personal data. Artificial intelligence can be a powerful ally in education if used responsibly and critically. Teachers must maintain a balance between technology and the human element in order to provide a high-quality and supportive learning environment.

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NOTES

1. Canva, 2025. https://www.canva.com/
2. Chartgo, 2025. https://www.chartgo.com/
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