TRADITION AND RENEWAL IN MATHEMATICS EDUCATION: EXPERIENCES AND CHALLENGES

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Abstract

The methods of mathematics have proven indispensable in the pursuit of numerous scientific disciplines, while the skills acquired through mathematical thinking can be applied in almost every area of life. However, learning mathematics is not merely a useful activity, but also an outstanding intellectual challenge. In response to this challenge, it is the task of mathematics educators to seize every available tool in order to bring this "royal science" closer to their students. At the University of Dunaújváros, therefore, the importance of teaching mathematical subjects is unquestionable, and it has also become a tradition to continuously incorporate the latest pedagogical and professional innovations into the methodology of these courses. This continuous renewal also represents an ongoing professional challenge for instructors. In our presentation, we review the main milestones that have characterized this developmental process at our institution, and then direct attention to the challenges currently experienced and those expected in the near future in the field of mathematics education – highlighting the dimensions of student success and artificial intelligence.

Keywords: pedagogical innovation, artificial intelligence, methodological renewal, student success, development of learning skills

1. Introduction

Mathematics is not merely a theoretical science, but an integral part of everyday life, providing indispensable assistance in numerous practical situations. Its most obvious applications appear in the area of financial decision-making: budget planning, defining savings goals, and calculating loans and investments all require mathematical thinking and computations. Similarly, during everyday shopping we frequently make comparisons based on unit prices, interpret discounts, or calculate the extent of price reductions. Transportation and travel planning also involve computational tasks: optimizing routes, estimating travel time, or calculating fuel consumption. Domestic activities such as construction, interior design, or home renovation make particular use of geometric knowledge and geometric calculations – for example, area or volume calculations. Mathematics also plays a key role in the development of a healthy lifestyle: determining body mass index, calculating daily calorie intake, and measuring athletic performance are all based on mathematical principles. The operation of modern technologies – especially digital tools and artificial intelligence – is likewise underpinned by complex mathematical models, algorithms, and statistical methods, which invisibly contribute to the efficiency and security of systems for everyday users. Finally, even seemingly simple activities such as planning a daily schedule or modifying the proportions of a recipe presuppose logical thinking, a sense of proportion, and basic operational skills.

All of these clearly demonstrate that mathematics is not abstract knowledge confined to school settings, but a living, practical tool that permeates almost every aspect of our lives. However, the role of mathematics extends far beyond this level: in higher

education and scientific research it also serves as a fundamental instrument for exploring the deeper interconnections of the world. Advanced mathematical methods are indispensable in the natural sciences, such as physics, chemistry, or biology, where modeling phenomena, making predictions, and interpreting data require complex analysis, differential equations, probability theory, and statistical procedures. In the engineering sciences – whether mechanical engineering, architecture, or computer science – mathematical background knowledge is likewise essential, as optimization, the analysis of structural stability, or the efficiency of algorithms all demand a solid mathematical foundation.
In recent years, remarkable progress has been observed in the fields of data analysis and artificial intelligence, where mathematics, particularly linear algebra, probability theory, and numerical methods, plays a crucial role. Machine learning algorithms, neural networks, and natural language processing are all applications whose operation can only be understood and developed on the basis of deep mathematical knowledge. Yet not only the "hard" sciences benefit from mathematics: economics, sociology, and even psychology increasingly rely on formal modeling and quantitative analyses. Through statistical inference, predictive models, and network-theoretical approaches, these disciplines also elevate their research methodologies to a new level.

In light of all this, it is clear that mathematics is not merely a tool, but a kind of universal language that enables deeper levels of scientific thinking. Therefore, it is particularly important that the development of mathematical literacy in public education be built on foundations that later enable learners to comprehend and apply higher levels of abstraction.
Building on the above-mentioned mathematical literacy, the development of these abstractions already takes place in higher education. Students entering universities not only deepen their previously acquired knowledge, but also acquire a higher-level mode of mathematical thinking, which is based on a balance between theoretical foundations and practical application. Linear algebra, calculus, discrete mathematics, probability theory, and mathematical logic are not self-serving subjects, but rather develop a structured way of thinking that facilitates a systemic approach to problems and their solutions. Thus, the mathematical knowledge acquired in higher education is not an end in itself, but can be directly utilized in the labor market as well. Employers increasingly seek professionals who are capable of interpreting data, optimizing processes, and developing decision-support models (Katona és Kővári, 2018). Mathematical competencies are particularly valuable in industry, the financial sector, and technology companies, but they are also gaining increasing importance in public administration and in the field of research and development. Mathematics therefore constitutes both a foundational and a widely applicable methodological base that enables graduates to adapt flexibly to rapidly changing technological and economic environments after completing their university studies. Analytical thinking, precision, and problem-solving skills – in the development of which mathematics plays a key role – can determine a professional's success in the long term.

However, due to its complexity and level of abstraction, mathematics poses difficulties for many learners; therefore, the effectiveness of instruction depends not only on the curriculum, but also to a large extent on the applied methodology. In order to convey the subject effectively, it is essential that instructors mobilize the broadest possible range of tools: alongside traditional frontal teaching methods, interactive learning organization techniques, the integration of digital tools, visualization-supporting software, as well as problem- and project-based approaches must also be employed. In addition, the application of methods that support differentiated learning is becoming increasingly important, enabling students arriving with different prior knowledge to find their own learning paths. Contemporary mathematics education is therefore not merely the transmission of knowledge, but the result of conscious pedagogical and methodological planning (Kocsó et al., 2020), (Kocsó et al., 2021). Only in this way can it be ensured that students not only acquire theoretical knowledge, but are also able to apply it flexibly in their own fields, and even to further develop and creatively utilize it (Kollár & Katona, 2024).

The modernity of mathematics education is today inseparable from the continuous development of technical and information technology innovations. Over recent decades, it has been clearly observable how the technological background of teaching and learning has evolved: while in the early 2000s the use of the Derive system represented a modern form of digital tool utilization, more recently Matlab and its substitute Octave have supported a deeper understanding of mathematical concepts and the practical solution of problems. The use of these tools not only facilitates conceptual development (Námesztovszki & Kővári, 2022), but also contributes significantly to the development of students' analytical and algorithmic thinking (Kovari, 2017 and Kovari, 2022). In addition, the learning process is increasingly supported by modern educational systems (Molnár, Szűts & Biró, 2018) and frameworks, such as Moodle (MOODLE, 2025), which not only enable access to learning materials (Blanco & Ginovart, 2012), but also offer structured assessment opportunities (Ahmed & AlShaqsi, 2024). Digital testing, self-assessment, and systems providing immediate feedback have by now become indispensable in courses with large student enrollments. All this draws attention to the fact that contemporary mathematics education must also be up to date in technological terms. Alongside the content of the curriculum, the form of instruction and its technical background play a decisive role in ensuring that students participate in the learning process in a motivated, active, and effective manner (Joós & Kővári, 2022).

2. Contemporary Methods in the Teaching of Mathematics

Nowadays, the application of artificial intelligence (AI) in education is unavoidable (Farkas, 2024): either the teacher considers it useful and introduces it into the classroom (Gligorea, 2025), (Gyonyoru, 2025), (Gyonyoru & Katona, 2025), or, if not encouraged by the instructor, students will use it anyway—often thoughtlessly (Bognár és Joós, 2025). It therefore appears much more appropriate for instructors to integrate AI into teaching practice. In the following, we present examples of several applications of open AI. (We note, however, that closed AI systems – e.g., GoSchoolAI (Németh et al., 2024) – have proven to be much more useful at the beginning of the learning process.) Accordingly, we consider an example related to a mathematics course at a regional university, for which the solution was provided using an open AI system (OpenAI, 2023). During the semester, students work, among other topics, on the direct and iterative solution of systems of linear equations, interpolation, numerical integration, and the numerical solution of differential equations.

3. An Example – Interpolation

The following task was given to the AI for solution:

During an experiment, two quantities were measured. The data are shown in the table below. Determine the cubic polynomial that fits these data.

x	1	2	4	7
y	1	8	2	5

In its response, the AI describes the solution procedure well, even if it sometimes uses unusual phrasing. We quote it below:

"Our goal is to find the cubic polynomial that passes through these points, that is:

$$P(x) = ax^3 + bx^2 + cx + d.$$

Since there are 4 points and 4 unknowns (a, b, c, d), we can write the equations:

$$a(1)^3 + b(1)^2 + c(1) + d = 1$$
$$a(2)^3 + b(2)^2 + c(2) + d = 8$$
$$a(4)^3 + b(4)^2 + c(4) + d = 2$$
$$a(7)^3 + b(7)^2 + c(7) + d = 5$$

Solution:

By solving the above system of equations, we obtain the coefficients of the polynomial.

I performed the calculation, the result is:

$$P(x) = -\frac{3}{10}x^3 + \frac{37}{10}x^2 - \frac{51}{5}x + \frac{49}{5}.$$

Verification (P(x) at the given points):

$$P(1) = -0.3 + 3.7 - 10.2 + 9.8 = 1$$
$$P(2) = -2.4 + 14.8 - 20.4 + 9.8 = 8$$
$$P(4) = -19.2 + 59.2 - 40.8 + 9.8 = 2$$
$$P(7) = -102.9 + 181.3 - 71.4 + 9.8 = 5\text{”}$$

This concludes the AI’s solution so far.
Unfortunately, the value of $P(2)$ is incorrect, as is the computed polynomial $P(x)$ itself. When the task was assigned again and the AI was warned that it had previously miscalculated, it eventually (on the third attempt) provided the correct result.

The reality is that when the AI is given a computational task, it does not actually perform “mental arithmetic” in the traditional sense, but rather proceeds through a process characteristic of a language model. First, based on linguistic patterns, it interprets the problem and identifies the appropriate mathematical method—such as solving equations, differentiation, or integration. It then generates the solution steps in textual form, meaning that it does not function as a system performing symbolic computations, such as WolframAlpha. The specific calculations—for example, the multiplication of large numbers—are not carried out algorithmically, but are instead reconstructed based on estimations within the language model. As a result, inaccuracies may occur, especially in more complex or multi-step operations.

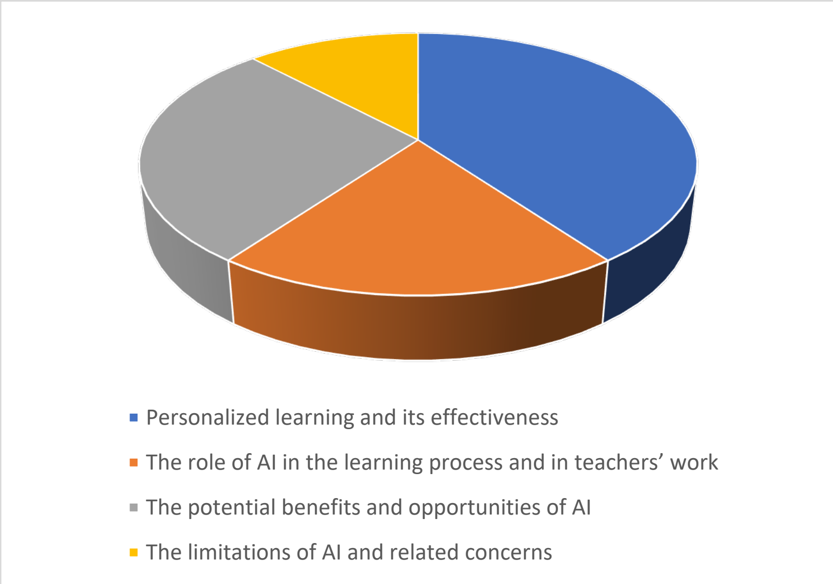
4. What Is AI Useful for at the University? – Student Responses

In the literature, the investigation of the application of AI and the acceptance of its use (Bo, 2025), (Crompton & Burke, 2023) has become a widely studied issue in recent years (Tick, 2019), (Zhou et al., 2024), (Çayak, 2024), (Fošner, 2024). In connection with the teaching of the course, we analyzed 25 student opinions. Based on student feedback, the role of artificial intelligence in education is multifaceted, but fundamentally complementary in nature. Several respondents highlighted that AI effectively supports learning, especially when understanding the course material poses difficulties. One student, for example, stated: “I mainly use it to explain what I don’t understand in class.” This clearly shows that AI can provide personalized assistance in the learning process.

In addition, AI can also support instructors, particularly in administrative tasks and in answering questions related to the course material. According to another student: “[AI] corrects homework and searches for information.” Thus, AI can alleviate the workload not only of students but also of instructors, thereby making the educational process more efficient. Several students also emphasized the role of AI in the development of the educational system. One opinion stated: “AI serves university courses primarily by personalizing learning, increasing the effectiveness of teaching, promoting critical engagement with AI, and supporting research. It should complement human teaching, not replace it, and the content it provides must be critically evaluated to ensure responsible and effective integration.” This approach interprets AI not merely as a tool, but as a factor that becomes part of the learning culture.

However, not everyone shares this positive view. One student expressed a skeptical opinion: “For nothing. Almost every problem that AI would solve can be traced back to constraints that, in an ideal case, would not be present in the first place.” This perspective highlights that the application of AI does not appear justified for everyone, particularly when the educational environment already functions adequately with human resources alone.

Figure 1. Advantages and disadvantages of AI from the students' Perspective



Overall, the majority of students view AI as useful but not as a standalone solution in education; it functions well when it does not replace human factors, but rather complements them.

5. Student Success

The examination of student success is crucial for evaluating the effectiveness of educational systems, as it extends not only to individual academic performance but also to institutional and pedagogical factors. Such analyses reveal weak points in the educational process, support developmental interventions, and assist in the more targeted design of student support systems (Kocsó, 2023). All of this contributes in the long term to the training of a competitive workforce, thereby fostering economic growth and strengthening social cohesion. Contemporary educational methods, including the application of AI, nowadays contribute to student success in a revolutionary way. AI not only supports the acquisition of learning material, but also addresses the emotional and cognitive dimensions of the learning process, with particular emphasis on maintaining motivation, curiosity, and interest. Through personalized learning pathways, AI is able to adapt educational content to students' individual learning styles and pace, thereby reducing frustration and increasing experiences of success, which play a key role in strengthening intrinsic motivation. Immediate and relevant feedback enables the rapid identification of errors and targeted development, while gamification elements and interactive learning environments enhance student engagement in a playful yet effective manner.

In maintaining curiosity, AI offers adaptive learning materials that are capable of deepening knowledge in alignment with students' interests. Interactive exploratory opportunities, such as virtual laboratories and simulations, create a safe and stimulating environment for experimentation, while intelligent tutors and chatbots, through their immediate responses, facilitate questioning and deeper understanding. The long-term maintenance of interest is further reinforced by AI's ability to connect learning material to students' real-life situations and future goals, as well as to present content in diverse formats—textual, visual, and interactive. Problem-solving-based tasks not only enable the application of knowledge, but also keep interest vivid through the experience of challenge and success.

Thus, AI becomes not merely a technological tool in education, but an intelligent partner capable of supporting students throughout every stage of the learning process in accordance with their individual needs. Through the combined strengthening of motivation, curiosity, and interest, AI contributes significantly to the improvement of learning outcomes and the enhancement of student success.

6. Summary

The teaching of mathematics—both at the secondary and higher education levels—builds a fundamental knowledge base that is indispensable not only for the practice of the discipline itself, but also for problem-solving and analytical thinking in a broader sense. During university education, this knowledge is further deepened, enabling students to adapt it to the specific requirements of their own fields. The development of the necessary levels of abstraction, as well as the understanding of practical applications, can only be effectively achieved in a modern, technologically up-to-date educational environment (Katona & Gyonyoru, 2025).
Over recent decades, technological development—particularly the spread of computer algebra systems and digital learning platforms—has significantly transformed the methodology of mathematics education. These tools not only enhance the effectiveness of visualization and practice, but also promote differentiated learning and independent knowledge acquisition. The new era of education is increasingly defined by the emergence of AI (Gyonyoru, 2024). AI-based systems—whether intelligent tutors, automated assessment algorithms, or personalized learning pathways—are capable of supporting student development (Galindo-Domínguez et al.s, 2024). Although AI may occasionally provide inaccurate responses, this does not diminish its substantive significance: when applied within an appropriate pedagogical framework, it can contribute to the maintenance of learning motivation, the development of deeper understanding, and the fostering of independent thinking. The success of modern mathematics education requires the conscious and critical integration of technological innovations—including artificial intelligence (Kocsó, 2023a). These developments can not only increase the effectiveness of education, but in the long term also strengthen students' professional autonomy and employability in the labor market.

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