Editorial

Mika Koskenoja[1] and Antti Viholainen[2]

[1] University of Helsinki, Finland
[2] University of Eastern Finland, Finland

DOI: https://doi.org/10.31129/LUMAT.14.1.3527
Contact: mika.koskenoja@helsinki.fi

Introduction

University level mathematics education typically involves a combination of lectures, seminars, and practical sessions. Students start with foundational courses such as calculus, linear algebra, and differential equations. As they progress, they delve into more advanced topics like abstract algebra, real and complex analysis, topology, and number theory. Mathematics programs often emphasize both theoretical understanding and practical application. Students learn to develop rigorous proofs, solve complex problems, and use mathematical software. Many programs also offer opportunities for research, internships, and collaboration with other disciplines such as physics, computer science, and engineering. This special issue addresses both theoretical and empirical contributions on the teaching and learning mathematics at the university level.

University teaching of mathematics and the level of its content vary greatly depending on the target group of the teaching. Departments of mathematics teach future mathematicians and researchers, who must learn the basics of basically all branches of mathematics developed to date. In addition, the focus must be on the latest research in a specific field, so that students can continue as experts and researchers in this field after completing their master's degree. Departments of mathematics also organize teaching for doctoral students, which differs from undergraduate teaching not only in terms of level but also in terms of methods, usually involving personal supervision.

On the other hand, mathematics is also taught at university to future secondary and comprehensive school subject teachers. In this case, the teaching and learning needs are partly different from those of future mathematics researchers. In addition to learning concepts and methods, it is necessary to emphasize how and what mathematical content is taught at school. In addition, mathematics is taught a lot in mathematics departments as service teaching to students in other fields, especially natural sciences, computer science and statistics, but also students in, for example, humanities, political science and economics need mathematics.

Two major upheavals have had a significant impact on higher education in mathematics in this decade. The first of these is the COVID-19 pandemic and the second is artificial intelligence. We will discuss these issues in the next two sections. Although neither the COVID-19 pandemic nor artificial intelligence are directly mentioned in all the articles in this special issue, it can be assumed that both have had an impact on all research on mathematics teaching and learning in recent years.

On the impact of the COVID-19 pandemic on university studies in mathematics

The sudden and rapidly spreading COVID-19 pandemic changed the arrangements for university studies in spring 2020. Universities quickly switched to an emergency remote teaching model and teaching mathematics proved particularly challenging (notation, symbolism, tools) (Ní Fhloinn & Fitzmaurice, 2021). There was no preparation for a large-scale transition to distance learning, but university departments had developed teaching methods that were suitable for distance learning. For example, the Department of Mathematics and Statistics at the University of Helsinki had been using the DIGest method for several years. DIGest is a flexible and collaborative method for organizing e-learning by self- and peer assessment of exercises (Koskenoja, et al., 2018). It works in the Moodle learning environment. Students anonymously score each other's solutions based on model solutions, and instructors monitor the assessments. The accumulated points usually weigh about one-third of the grade, with the main emphasis on exam scores. Almost all basic and intermediate level mathematics and statistics courses adopted the DIGest method in their teaching and used it throughout the pandemic, and many courses are still using it. A key feature of the method is that the exercises can be implemented in a way that students receive feedback on each solution to the exercise.

The pandemic caused a statistically significant decline in learning levels, and mathematics suffered more than many other subjects (Gianfredi, et al., 2024). Ortega-Barba et al. (2024) also observed that distance learning significantly weakened mathematics skills. Mathematics assessment practices changed radically during the pandemic (Ní Floinn & Fitzmaurice, 2025). Closed exams were often replaced by open-book exams and continuous assessment. Moreover, teacher satisfaction with assessment decreased during the pandemic. Regarding the DIGest method discussed above, exercise activity can be meaningfully taken into account in the course evaluation.

Students who completed high school during the pandemic entered university with significantly weaker mathematical skills and diagnostic tests show a decline in proficiency levels (Hodds, 2023). Many students suffered from the lack of social contact at university, neither with other students nor with teachers. Many who started their university studies during or just after the pandemic have still not fully recovered from the difficulties they experienced in progressing their studies. The increased need for support has been identified and universities have done a lot to ensure that students complete their studies. For example, students are assigned a tutor who guides them through their studies and can always be contacted when the need arises.

On the use of AI in university mathematics studies

As in other fields and levels of education, university-level mathematics teaching has been affected by the explosive growth in the use of artificial intelligence (AI) in recent years. The use of AI enables many things in teaching and learning that were not possible before. Many of these possibilities are useful, but unfortunately, students can also use artificial intelligence in ways that make learning mathematics difficult. Our own empirical observations in the courses we teach suggest that the solutions to the homework problems are too often entirely generated by AI, which means that students' own thinking is neglected. In this case, learning mathematics only occurs superficially, if at all.

The strong increase in the use of AI in the study of mathematics will inevitably affect the arrangements for teaching. In some arrangements, it is necessary to return to old methods, for example, the weight of supervised tests must be increased in grading. Correspondingly, the weight of work completed independently in one's own time must be reduced as part of grading. It is a pity that the diversified methods of course delivery and grading of the last two decades have to be partially replaced by traditional methods, for example with use of pen and paper.

To counterbalance the concerns surrounding the use of AI, there are many opportunities brought by the use of AI in mathematics education, see e.g. (Tang, 2025). For example, AI adapts to individual student needs, increases engagement, promotes deeper understanding of mathematical concepts and fosters inclusive learning environments, particularly students with special needs. Yavich (2025) found that AI tools (e.g. ChatGPT) improved learning outcomes and motivation, especially with low-achieving students. They provide step-by-step solutions and immediate feedback.

Three articles published in this special issue discuss the use of AI related to higher education in mathematics.

Papers included in the current issue

This special issue contains eight papers on different areas of higher education in mathematics. They provide interesting perspectives on teaching and learning mathematics at the university level. Teacher education and use of AI or other technology are central topics in several papers in this issue. Often the focus of research is in how mathematical understanding, reasoning or problem solving can be supported in a learning environment which is affected by technology.

In the first paper, Gómezescobar, López-Iñesta, Sanz and Santágueda-Villanueva present “Aula de Apoyo,” a service-learning programme in which undergraduate education students provide extracurricular mathematics support to low-achieving primary school pupils while developing their own teaching skills. The results show that the programme enhances learning and educational equity and fosters key transversal skills such as empathy and adaptability, helping prepare future teachers for the challenges of a rapidly changing society.

Sjaastad and Lorange explore how a dynamic learning environment supports pre-service teachers in generalizing figural patterns, using Duval’s theory to analyze their reasoning processes. While participants generated multiple valid symbolic generalizations and experimented with the tool, they showed weaknesses in justifying generalizations, often relying on single examples and struggling to articulate generalized structures, raising concerns about their algebraic thinking.

Burgos and Tizón-Escamilla examine how prospective mathematics teachers use ChatGPT to generate algebra-related problems, focusing on their ability to instruct the tool and evaluate its outputs. The findings reveal significant difficulties in prompting effectively for ChatGPT, and identifying errors in ChatGPT responses, resulting in problems that often fail to support algebraic reasoning. The authors conclude that in teacher education didactic-mathematical training is needed for efficient use of ChatGPT to pose meaningful mathematical problems.

Nyman studies the challenges pre-service elementary teachers face in teaching mathematical problem-solving, particularly due to limited knowledge of strategies and unproductive beliefs about instruction. Findings from an intervention highlight key difficulties in lesson design and implementation, offering insights for improving teacher education to better support effective problem-solving instruction.

Kuzle examines prospective primary mathematics teachers' professional knowledge of concept formation using the "House of Quadrilaterals" after a two-semester geometry course. While most participants showed satisfactory overall performance, qualitative analysis revealed notable gaps in both content knowledge and pedagogical content knowledge, highlighting challenges in addressing student misconceptions and linking tasks to specific knowledge facets, with implications for improving teacher education.

Bui, Vinerean-Bernhoff and Liljekvist investigate how pre-service and in-service mathematics teachers in Sweden integrate generative AI in mathematics education, focusing on readiness, usage patterns, and differences between career stages. The findings show that both pre-service and in-service mathematics teachers have similar readiness levels for use of AI. However, pre-service teachers tended to use AI more on learning, whereas in-service teachers applied it in a more selective and professionally informed way.

Lahdenperä, Kevarinmäki, Kokkonen and Hynninen examine the development of abstract mathematical and applied physical competence in a university physics intervention course, focusing on students' understanding of vectors. The results show that improvements were mainly in applied physical competence and support the idea that such development depends on a foundational level of mathematical understanding, while persistent misconceptions highlight the need for more targeted teaching approaches.

In the last paper of this special issue, Abrigana, Caruana, Obcianal, Templa, Aleguen and Elladora investigate pre-service mathematics teachers' use of AI-powered math platforms (AI-PMPs), examining both their impact on performance and students' experiences through a mixed-methods approach. The results indicate that while usage frequency does not significantly affect mathematics performance, AI-PMPs can serve as useful supplementary tools, though students should avoid overreliance and use them in a balanced way.

References

Gianfredi, V., Scarioni, S., Marchesi, L., Ticozzi, E. M., Obene Addo, M., D'errico, V., . . . Castaldi, S. (2024). Covid-19 pandemic and student academic performance: a systematic review and meta-analysis. *European Journal of Public Health, 34 (Suppl 3)*. doi:10.1093/eurpub/ckae144.1995

Hodds, M. (2023). The impact of COVID-19 on mathematical entry competencies: 1 year on. *Teaching Mathematics and its Applications: An International Journal of the IMA, 42*(4), 343-359. doi:10.1093/teamat/hrac023

Koskenoja, M., Varvio, S.-L., Piiroinen, P., Leivonen, A., Lehtonen, T., Nuutinen, J., & Rantanen, N. (2018). DIGest: digital method for self and peer assessment of exercises in mathematics and statistics university studies. In D. Remenyi (Ed.), *4th e-Learning Excellence Awards 2018: An Anthology of Case Histories* (pp. 123-130). Reading, United Kingdom: Academic Conferences and Publishing International Limited.

Ní Fhloinn, E., & Fitzmaurice, O. (2021). How and why? Technology and practices used by university mathematics lecturers for emergency remote teaching during the COVID-19 pandemic. *Teaching Mathematics and its Applications: An International Journal of the IMA*. doi:10.1093/teamat/hrab018

Ní Floinn, E., & Fitzmaurice, O. (2025). The impact of the COVID-19 pandemic upon mathematics assessment in higher education. *Education Sciences, 15*(4), 449. doi:10.3390/educsci15040449

Ortega-Barba, C. F., Ramírez-Pérez, H. X., & Méndez-Padilla Andrade, S. (2024). Who are we receiving at the university? The impact of COVID-19 on mathematics and reading learning in high school. *Frontiers in Education, 9:1356730*. doi:10.3389/feduc.2024.1356730

Tang, W. K.-W. (2025). Artificial intelligence in mathematics education: trends, challenges, and opportunities. *International Journal of Research in Mathematics Education, 3*(1), 75-90. doi:10.24090/ijrme.v3i1.13496

Yavich, R. (2025). Improving learning outcomes in advanced mathematics for underprepared university students through AI-driven educational tools. *African Educational Research Journal, 13*(2), 224-239.