AI-BASED MATHEMATICS LEARNING PLATFORMS IN UNDERGRADUATE ENGINEERING STUDIES: ANALYSES OF USER EXPERIENCES

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Abstract. Artificial intelligence is becoming more popular between students in higher education helping students in finding answers faster and easier and augment the educational process. Although the educators usually consider artificial intelligence as a threat to educational processes, however artificial intelligence is a leap across creative and innovative thinking in various fields, including mathematics education. Several studies have shown that artificial intelligence allows students to develop and improve more mathematical skills and cognitive skills in learning. It can help students explore more without waiting for an educator. The purpose of the study is to identify what kind of artificial intelligence - based platforms are used by students in undergraduate engineering mathematics studies, to collect the users - students and teachers experience of using them and to perform a comparative analysis of two countries - Latvia and Estonia, identifying the main challenges and considerations for the use of artificial intelligence - based mathematics learning platforms in mathematics studies at universities. Research tasks include identification of AI-based mathematics learning platforms such as Photomath, Desmos, GeoGebra, Maplesoft, Matific, Carnegie Learning, Microsoft Math Solver, ASSISTments, Fishtree, ALEKS, Symbolab, Cognii, Gradescope, Acadly, Maple Calculator as well as chatbot ChatGPT, and analysis of scientific literature on the benefits of their use in mathematics studies. Empirical research includes a survey of undergraduate students in both countries as well as focused interviews of the teaching staff. The research results show that the most popular tools in both countries are Photomath, chatbot Chat GPT as well as Symbolab, complemented by GeoGebra in Estonia and Desmos in Latvia.

Keywords: artificial intelligence, mathematics learning platforms, engineering studies.

Introduction

Artificial intelligence (AI) has become an integral part of social and educational environments, and is a widely available tool for anyone with access to the Internet. It has also entered higher education. Several experts claim that in 2023, generative artificial intelligence has become a significant initiator of the change, which will significantly affect teaching and learning methods, and its transformative potential in education is undeniable, which determines the need to strategically revaluate the integration of technology in various processes, including education. Therefore, in April last year, the Latvian Council of Higher Education adopted the "Notice on the use of AI tools in higher education and research", which, among other things, indicates the need to include the responsible use of AI tools in the study programs of universities in order to prepare the next generation of specialists who are able to use and develop these technologies in the interest of the whole society. Referring to this, the Riga Stradins University has developed a support material for lecturers "Artificial intelligence in higher education" [1], which describes the approach to the use of AI in the study process, provides recommendations for the academic staff and students for the responsible use of AI, the approach to combining AI solutions with traditional learning and teaching methods, etc.

AI has the potential to significantly change the course of education and the environment [1], transform and promote the instructional and learning design, process and assessment [2]. In connection with the use of artificial intelligence in higher education, three main areas are identified: pedagogical, operational (infrastructure and training) and governance (legal and ethical issues in the use of AI) [2], with the pedagogical dimension understanding the use of AI to improve teaching and learning outcomes [2,3,4], develop creativity as well as help improve mathematical skills [3]. Educational research shows that using AI in mathematics studies can improve academic achievement by up to 30% [5]. AI helps students find the necessary information faster and easier [6], without waiting for the teacher's help, but providing a personalized approach for each user [1,7]. The use of artificial intelligence in mathematics studies can improve student motivation to learn mathematics [8], make lessons more interesting and engaging through interactive tasks [9] etc. In general, the integration of AI in the study process has significant benefits, which will be able to promote the acquisition of higher-level skills and ensure a higher quality study environment [1]. Therefore, the issue of the use of AI in mathematics studies is also

brought up, which determines the need to conduct a study of the current situation, recognizing the experience and expectations of users.

Materials and methods

The study addresses the following research questions.

1. What are the most frequently utilized ICT tools and AI-based mathematics learning platforms among engineering students in Latvia and Estonia for comprehending mathematics concepts and completing independent tasks?
2. How do Latvian and Estonian students perceive the effectiveness of AI-based mathematics learning platforms for different mathematical topics, and what features do they find most useful?
3. What challenges do students face while using AI-based mathematics learning platforms, and how can these platforms be enhanced to support the needs of engineering students better?

Based on the above-mentioned considerations, the research methodology, aimed at identifying the situation from the users' perspective, includes the use of information and communication technologies (ICT) tools created as a result of the digitization of the study process (various learning materials in university e-study systems or on the Internet) and the use of AI-based mathematics learning platforms, determined using the AI Wiki "Top 15 AI-Based Mathematics Learning Platforms for Students and Teachers in 2023". Here, with AI-based math learning platforms understood tools (including math software) that can intelligently support online math learning, provide interactive concept visualization, automated assessment, one-on-one tutoring, personalized learning experiences, and more.

The evaluation of the functionality of AI-based mathematics learning platforms is based on Schiff's findings [10], which state that in the context of higher education, the ability of AI to imitate a human can be used in various ways, such as individualizing learning, constant feedback and providing answers to the questions the student needs at the right time and level, also adapting learning tasks to students' needs.

In terms of data collection, online questionnaires through Google Forms were used as the method to answer the research questions. This survey was distributed among the first-year students at three institutions: the Estonian University of Life Sciences (EMU), TTK University of Applied Sciences (TTK UAS) and the Latvian University of Life Sciences (LLU) using e-learning systems. The study sample consisted of 100 engineering students: 59 from Estonia and 41 from Latvia. Data were collected in the spring semester of the 2023-2024 academic year.

Results and discussion

To address research questions regarding the use of artificial intelligence-based platforms in undergraduate engineering and mathematics courses among Latvian and Estonian students, as well as to conduct a comparative analysis between the two countries, data obtained from questionnaires were analysed. To ensure a fair comparison between Latvian and Estonian students, whose sample sizes differed in our study, data analyses were performed as percentages rather than raw counts. The quantitative results of the study were analysed using descriptive statistics (9 questions), while content analysis was used for qualitative data obtained from open-ended questions (2 questions).

Based on the results of the use of ICT tools and maths software to understand maths concepts and complete independent work tasks, notable differences emerged between Latvian and Estonian students. Among Latvian students, 37% reported regularly using lecture notes and electronic materials to understand maths concepts, and 44% indicated frequent use of these resources. Surprisingly, only 5% of Latvian students reported, that they do not use these resources at all. In contrast, among Estonian students, a smaller proportion (17%) reported regularly using lecture recordings and online learning materials, with 25% using these resources frequently. Moreover, a relatively larger percentage (14%) of Estonian students admitted that they do not use these resources at all. When solving problems using examples, only 6% of Estonian students and 10% of Latvian students do not or rarely use ICT tools. When examining the use of online video tutorials, a similar trend was observed among Estonian and Latvian students. Approximately 12% of Estonian students and 17% of Latvian students reported regular utilization of online video tutorials. Furthermore, 29% of Estonian and 20% of Latvian students indicated frequent use of these resources. Conversely, a notable proportion of students from both

countries reported rarely using online video tutorials, with 46% of Estonian students and 51% of Latvian students falling into this category. Interestingly, a minority of students, comprising 14% of Estonian students and 12% of Latvian students, admitted to never using online video tutorials. In general, when using the various available online materials, Estonian students are more active, with 36% using them regularly and 51% often while only 32% of Latvian students use online materials regularly (20%) or often (12%) (see Table 1).

Table 1

ICT tools and maths software used by students to understand maths concepts and solve independent work tasks

Statement	Country	Regularly	Often	Rarely	Never
I use lecture recordings/study e-materials	LV	37%	44%	15%	5%
	EE	17%	25%	44%	14%
I learn from the problem-solving examples	LV	44%	46%	10%	0%
	EE	42%	51%	3%	3%
I look for video tutorials online (YouTube, etc.)	LV	17%	20%	51%	12%
	EE	12%	29%	46%	14%
I use various learning materials available on the internet	LV	20%	12%	44%	24%
	EE	36%	51%	10%	3%

To evaluate different AI-based mathematics learning platform use in undergraduate engineering studies, students were asked to rate the use of the following platforms on a 4-level Likert scale (regularly, often, rarely, never) AI-based mathematics learning platforms such as Photomath, Desmos, GeoGebra, Maplesoft, Matific, Carnegie Learning, Microsoft Math Solver, ASSISTments, Fishtree, ALEKS, Symbolab, Cognii, Gradescope, Acadly, Maple Calculator as well as Chatbot ChatGPT.

The analysis of the results revealed distinct preferences among students in Latvia and Estonia. In Latvia, students primarily rely on Photomath and Chatbot for their mathematical studies, while in Estonia, Photomath, Geogebra, and Chatbot are the most commonly utilized tools. The widespread adoption of Geogebra in Estonia can be attributed to its integration into the secondary school curriculum, particularly at the upper secondary level. Additionally, the popularity of Photomath in both countries may be attributed to its accessibility via mobile devices, facilitating convenient usage for students. As it can be seen in Table 2, the Desmos platform is used more often in Latvia than in Estonia, while Microsoft Math Solver is used equally rarely in both countries. The other named AI-based math learning platforms are not popular among the students who participated in the study - they are rarely used in Latvia by around 10%, and in Estonia by only around 2%.

Table 2

AI-based mathematics learning platforms used by students

Statement	Country	Regularly	Often	Rarely	Never
Photomath	LV	56%	27%	5%	12%
	EE	49%	27%	12%	10%
Desmos	LV	7%	2%	24%	63%
	EE	5%	2%	10%	81%
GeoGebra	LV	2%	0%	24%	71%
	EE	14%	20%	46%	19%
Symbolab	LV	10%	2%	17%	63%
	EE	2%	12%	15%	68%
Chatbot ChatGPT	LV	17%	17%	41%	32%
	EE	46%	27%	12%	14%
Microsoft Math Solver	LV	0%	2%	17%	71%
	EE	0%	2%	17%	76%

The effectiveness of AI-based mathematics learning platforms varied across different subjects, with notable differences observed between Estonian and Latvian respondents. Both Estonian and Latvian respondents identified AI-based platforms as highly effective for learning algebra, with 62.7% of

Estonian respondents and 67% of Latvian respondents expressing this view. In Estonia, 45% of respondents found AI-based platforms effective for geometry, compared to 35% in Latvia. This trend may be attributed to the popularity of GeoGebra in Estonian schools, as evidenced by its usage among respondents (48 out of 59 in Estonia and only 11 in Latvia). In Estonia, a majority of respondents deemed derivatives (64%) and integration (66.1%) highly effective, while in Latvia, 43% of respondents considered derivatives effective, but only 32% found integration effective. Notably, the topic of limits could not be directly compared due to differences in curriculum coverage. In terms of statistics, 49.2% of Estonian respondents considered AI-based platforms effective, whereas only 32% of Latvian respondents shared this view. These findings highlight the varying perceptions of AI-based mathematics learning platform effectiveness across different subjects, suggesting potential differences in curriculum emphasis and educational practices between Estonia and Latvia.

The most useful features in AI-based mathematics learning platforms offered to students were identified as interactive exercises, personalized learning paths, instant feedback, virtual tutoring, and progress tracking. Among Estonian students, interactive exercises were deemed particularly important by 50.8%, and virtual tutoring by 57%, while in Latvia, these features were valued by 28.2% and 23.1%, respectively. Personalized learning paths and progress tracking were highlighted as essential features by Latvian students, with 48.7% and 41%, respectively, while in Estonia, only 18% and 25% of respondents emphasized their importance. Immediate feedback emerged as crucial for both Estonian and Latvian students, with 57% and 61%, respectively, emphasizing its significance. These findings underscore the differing preferences and priorities of students regarding the features offered by AI-based mathematics learning platforms, indicating potential areas for customization and improvement tailored to each country's educational context (see Table 3).

Table 3

Evaluation of features of AI-based mathematics learning platforms from the students' perspective

Country	Interactive exercises	Personalized learning paths	Instant feedback	Virtual tutoring	Progress tracking
LV	28.2%	48.7%	61.5%	23.1%	41%
EE	50.8%	18.6%	57.6%	57.6%	25.4%

The predominant device used by students to access AI-based mathematics learning platforms is the telephone, with usage rates of 94.5% in Estonia and 97.5% in Latvia. Laptops are also commonly utilized, with 83.1% of Estonian students and 65% of Latvian students reporting their usage. Computers are used by a smaller proportion of students, with 27% in Estonia and 37% in Latvia. Tablets are the least popular device, with usage rates of 6% in Estonia and 0% in Latvia.

Regarding the perceived improvement in mathematics skills following the utilization of artificial intelligence-based mathematics learning platforms, 59.3% of students in Estonia and 58.5% in Latvia reported noticing enhancements. Conversely, 33.9% of Estonian students and 26% of Latvian students expressed uncertainty regarding any improvement (see Table 4).

Table 4

Improvement in mathematical skills since using AI platforms

Country	Yes	No	Not sure
LV	58.5%	14.6%	26.8%
EE	59.3%	6.5%	33.9%

Challenges encountered while using artificial intelligence-based mathematics learning platforms were varied. Technical issues were reported by 35.6% of respondents in Estonia and 22% in Latvia. Limited content was a concern for 54.9% of Estonian respondents and 56.1% of Latvian respondents. Low engagement was mentioned by 8.5% of respondents in Estonia and 9.8% in Latvia. Additionally, other challenges were cited by 6.8% of respondents in Estonia and 12.5% in Latvia.

On the question of additional features of AI-based mathematics learning platforms, 30% of respondents from both countries expressed interest in gamification elements. Integration with engineering software generated significant interest: 72.9% of respondents from Estonia and 62.5% of

respondents from Latvia expressed a desire for such integration. In addition, there was a noticeable interest in collaborative learning tools, as indicated by 47.5% of respondents from Estonia and 55% of respondents from Latvia. It is interesting, that 2.5% of Latvian respondents preferred the options "can perform all actions" and "nothing", while these options were not chosen by Estonian respondents (see Table 5).

Table 5

Additional features of AI-based mathematics learning platforms from student perspective

Country	Gamification elements	Integration with engineering software	Collaborative learning tools	Able to perform all actions
LV	30%	67.5%	55%	2.5%
EE	30.5%	72.9%	47.5%	0%

When asked whether they would recommend AI-based mathematics learning platforms to their peers, 54.6% of respondents in Estonia and 41.5% in Latvia expressed a strong inclination to do so. Additionally, 39% of respondents in Estonia and 34.1% in Latvia indicated they would probably recommend them. However, a small proportion of respondents were uncertain, with 3.4% in Estonia and 9.8% in Latvia not sure about recommending these platforms. Similarly, a small percentage would probably not recommend them, with 3.4% in Estonia and 14.6% in Latvia expressing reservations about doing so.

In response to how AI-based platforms can better serve engineering students, Latvian participants provided 21 responses. Some expressed uncertainty or lack of knowledge about potential improvements, while others emphasized the need for content in Latvian for better understanding. Suggestions were made to specialize AI platforms in specific research areas, with mentioning of Microsoft Copilot as a potential enhancement tool. Participants stressed the importance of broader solution capabilities, accuracy, and step-by-step explanations to expedite learning. While some found current AI platforms satisfactory, others requested more clarifying steps in problem-solving processes. AI platforms were praised for saving time and providing cost-effective solutions. Estonian participants (39 responses) echoed similar sentiments, emphasizing better explanations, comprehensive answers, and accessible platforms. However, some expressed uncertainty about AI effectiveness for complex tasks. Latvian respondents (7 responses) offered diverse opinions, including requests for localized content and concerns about AI-generated content quality. In response to an open-ended question, Estonian participants suggested AI improvements, while Latvian respondents expressed varying opinions and experiences with AI platforms.

As we can see, the study shows that Photomath is the most used AI-based math learning platform. According to the AI Wiki, Photomath is a mobile app that recognizes both handwritten and printed maths problem and instantly gives a step-by-step solution. The main advantage of this application for both teachers and students is that you can quickly check the work and identify mistakes. Obviously, this is why this platform is so popular among undergraduate engineering students.

However, there are also some limitations here, because according to Webel and Otten [11], "in the conceptual problems, Photomath can assist only with computations; it cannot generalize the patterns". This platform helps reduce calculations, resulting in increased problem-solving opportunities, but mathematics teachers must ensure that the results are evaluated in a reasonable way and the results can be applied to specific situations. It has been shown that AI will never deliver significant improvements in learning unless accompanied by the right strategy [12].

Conclusions

1. The use of ICT tools and mathematics software among engineering students in Latvia and Estonia shows different preferences, with Photomath and Chatbots being common choices, and complemented by GeoGebra in Estonia due to their integration into secondary education.
2. Latvian and Estonian students have different perceptions of AI-based mathematics learning platforms. While both countries rate AI platforms as highly effective for algebra, Latvian students rate them lower in their performance in geometry, derivatives, integration, and statistics compared to Estonian students. Notably, Latvian students prioritize personalized learning and progress tracking, while Estonian students value interactive exercises and virtual learning.

3. Challenges faced by students using AI platforms include technical issues, limited content, and low levels of engagement. Respondents from Latvia highlight difficulties with translated content and advocate for more tailored materials, while respondents from Estonia highlight the need for better explanations and step-by-step solutions.
4. To better support engineering students, it is recommended to improve the user interface, expand the capabilities of the solution, and provide more accurate and complete answers. Additionally, integration with engineering software and collaborative learning tools may improve the effectiveness of AI platforms for this population.

Author contributions:

Conceptualization, A.V.; methodology, A.V. and E.S.; software, A.V.; validation, E.S. and O.P.; formal analysis, O.P.; investigation, A.V., E.S. and O.P.; data curation, O.P.; writing – original draft preparation, A.V.; writing – review and editing, A.V. and E.S.; visualization, A.V., E.S. and O.P.; project administration, A.V.; funding acquisition, A.V. All authors have read and agreed to the published version of the manuscript.

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