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MATHEMATICS FOR FUTURE ENGINEERS: STUDENT ATTITUDES, LEARNING STRATEGIES, AND THE ROLE OF TECHNOLOGY

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ABSTRACT

In engineering education, mathematics plays a key role not only in developing basic numerical competence but also in facilitating the understanding of advanced concepts and the development of critical reasoning. As technological innovation accelerates, particularly with the rise of artificial intelligence and data-driven systems, mathematics becomes increasingly important in engineering education, providing students with the skills needed to engage with complex problems and advanced reasoning. This study examines engineering students' attitudes toward mathematics, their learning approaches, and the role of information technology in the learning process. A questionnaire-based survey was conducted among 269 engineering students from the University of Belgrade and the University of Novi Sad. The results indicate that engineering students generally hold positive attitudes toward mathematics. They tend to prioritize solving tasks over understanding theoretical content, and peer interaction emerges as an important learning resource. The study also explores differences in attitudes based on gender, previously completed courses, and year of study. Findings of this study underscore the importance of aligning mathematics instruction with students' perspectives and learning preferences. The study recommends strengthening theoretical learning through interactive, technology-supported environments that foster deeper mathematical engagement and critical thinking in engineering education.

Keywords: Engineering students, attitudes toward mathematics, engineering education, learning approaches, technology-supported learning.

INTRODUCTION

Mathematics represents a fundamental component of engineering education, forming the basis for analytical reasoning, modeling, and decision-making across a wide range of technical domains (Flegg et al., 2012). Engineering students are routinely required to engage with mathematical concepts not only throughout their academic studies, but also in practical problem-solving and interdisciplinary collaboration in their future professional roles.

Understanding how students perceive the role of mathematics in their education can inform instructional design and contribute to more effective teaching and learning environments. Prior research has shown that student attitudes toward mathematics, self-confidence in their mathematical abilities, and individual learning approaches can significantly influence academic performance and long-term engagement in STEM fields (Ahmed et al., 2012; Kloosterman et al., 2008). Moreover, variations in students' educational backgrounds such as the type of secondary school attended or the number of mathematics courses completed may be reflected in their study habits and learning preferences (Tamar & Kohen, 2022).

The integration of digital technologies into the learning process has also become increasingly relevant. The use of ICT tools, including mathematical software, online platforms, and, more recently, AI-based assistants, offers new opportunities for personalized and flexible learning in mathematics (Guler et al., 2024; Li et al., 2010). However, student engagement with these

resources often varies, depending on their learning strategies, previous experiences, and perceived usefulness of the tools.
This study aims to explore engineering students' attitudes toward mathematics, their use of information and communication technologies in learning, and their preferred learning strategies. By examining how these aspects relate to variables such as gender, academic year, and educational background, the research seeks to provide insights that can support evidence-based pedagogical improvements in engineering education.

LITERATURE REVIEW

Attitudes towards mathematics

A substantial body of research confirms that engineering students' attitudes toward mathematics exert a decisive influence on both their academic performance and their willingness to engage deeply with the subject. The literature converges on several interrelated themes that shed light on the factors shaping these attitudes.

Many engineering students enter university with limited confidence in their mathematical capabilities, which can immediately constrain their academic performance. Conversely, students who believe in their capacity to master mathematical tasks and who possess strong self-efficacy consistently achieve better results and express more positive attitudes, regardless of their prior preparation (Panaoura et al., 2024; Shamsuddin et al., 2018).

Attitudes are also shaped by the extent to which students recognize mathematics as integral to engineering practice. Those who understand the relevance of mathematical knowledge to solving real-world problems tend to demonstrate greater persistence and interest in learning mathematics. The belief that mathematical tools are essential for engineering tasks strengthens their motivation and engagement (Zavala & Dominguez, 2016; Panaoura et al., 2024).

Empirical studies also point to persistent gender-based differences in students' attitudes toward mathematics. Male students generally report more favorable beliefs about the nature of mathematics and their ability to learn it, while female students are more likely to experience mathematics anxiety. This anxiety has been shown to negatively affect both attitudes and academic performance in STEM fields (Maat et al., 2010; Megreya et al., 2025).

Teaching practices that emphasize the practical applications of mathematics, such as solving authentic engineering problems, have the potential to improve students' attitudes and outcomes. Interventions aimed at boosting confidence, reinforcing the usefulness of mathematics, and providing timely support are particularly beneficial. Such approaches help foster students' interest and motivation, which in turn enhances their engagement and achievement (McDonald & Brooks, 2021; Villar-Sánchez et al., 2022; Shamsuddin et al., 2018).

Finally, research suggests that students' attitudes toward mathematics may change over time. First-year students often begin their studies with relatively positive perceptions, but enthusiasm and confidence can decline as they progress through their programs. This trend highlights the need for continuous support and well-designed instructional strategies that maintain students' interest and reinforce the importance of mathematics in engineering (Villar-Sánchez et al., 2022; Zavala and Dominguez, 2016).

Usage of ICT for learning mathematics

The use of information and communication technologies (ICT) in engineering mathematics education has diversified significantly in recent years, with students employing a variety of digital resources to support different aspects of their learning. Research shows that engineering students rely on digital tools not only for procedural tasks but also for conceptual understanding and self-regulated study paths (Pepin et al., 2021). For example, Kock and Pepin (2018) observed that first-year students drew on secondary school habits and emulated familiar learning strategies when navigating digital and material resources in Calculus and Linear Algebra courses. However, without explicit guidance, this transfer often led to difficulties, emphasizing the need for better support in resource management.

Digital environments allow for greater flexibility and personalization in learning, accommodating the heterogeneous backgrounds of engineering students. Tools such as online modules, adaptive tutorials, and interactive videos offer students the ability to choose between lecture-based or self-paced content delivery, depending on their preferences and needs (Howard et al., 2018; Pepin et al., 2021). Moreover, dedicated software, including CAS systems and spreadsheet tools, are not only used for computation but also to verify solutions and encourage reflective engagement with mathematical content (Van der Wal et al., 2019).

Nevertheless, the effectiveness of ICT tools depends largely on their pedagogical integration. Studies warn that poorly designed tasks within digital platforms may allow students to obtain correct answers without a genuine understanding of the underlying mathematics, as demonstrated in Kanwal's (2020) analysis of Maxima use within MyMathLab. These findings underscore the importance of aligning technological resources with instructional goals to foster meaningful mathematical activity and support conceptual learning.

Learning habits

Learning habits among engineering students in the field of mathematics show considerable variation, particularly in terms of how students sequence their engagement with theoretical content and problem-solving tasks. While some prefer to begin by tackling exercises and consult theoretical concepts only when necessary, others follow a more structured path, first focusing on understanding the theory before moving on to problems (Havola, 2020). These contrasting strategies reflect broader individual differences that stem from students' previous educational experiences, self-concepts, and expectations. It is common for students to continue using learning methods developed during secondary education, including the order in which they approach content, suggesting a certain consistency in learning preferences over time (Havola, 2020).

Moreover, learning strategies are not static; many students revise their approach as a result of academic setbacks. For example, after underperforming on initial assessments, some adapt by changing the order in which they engage with theoretical and practical material. This type of adjustment highlights the dynamic nature of learning and emphasizes the importance of identifying which strategies best support different learner profiles within engineering education (Havola, 2020).

However, for many students, merely having access to content in a general format may not be effective (De Melo et al., 2014; Maric et al., 2015). In addition to traditional lectures, instructors can support deeper learning by offering enhanced guidance, such as advance organizers, summaries, repetitions, and targeted questioning (Gehlen-Baum & Weinberger, 2014). Ultimately, there remains a gap in our understanding of undergraduate study behaviors, as few factors beyond non-cognitive traits have proven explanatory power (Delaney et al., 2013).

Methodolgy

Participants

The study included a total of 269 undergraduate engineering students from two institutions: the Faculty of Technical Sciences at the University of Novi Sad and the Faculty of Mechanical Engineering at the University of Belgrade. Since no statistically significant differences were observed between students from the two faculties across any of the analyzed variables, they were treated as a single sample of engineering students in subsequent analyses.

Of the total sample, 188 students (69.9%) were male and 81 students (30.1%) were female. Regarding their academic year and exposure to mathematics courses, 118 students (43.9%) were first-year students who had completed one mathematics course, while 151 students (56.1%) were third-year students who had successfully completed multiple mathematics courses.

The study also considered the type of secondary education as a potentially relevant variable. Among the participants, 181 students (67.3%) had completed grammar school, whereas 88 students (32.7%) had completed vocational secondary school.

Procedure

Data were collected using a structured questionnaire designed to examine three key dimensions of students' experience with learning mathematics (Fig. 1): (1) attitudes and self-assessment, (2) the use of information and communication technologies (ICT), and (3) learning strategies. The questionnaire was based on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Students completed the questionnaire voluntarily after attending regular lectures in the classroom setting.

Attitudes and Self-Assessment in Learning Mathematics

The first subscale focused on students' attitudes toward mathematics and their self-perceptions as learners. It included items addressing the following aspects: motivation and emotional engagement, self-assessment of mathematical competence, perceived importance of mathematics, its usefulness in real-life and professional contexts, and preferred learning depth and style. This subscale demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient of 0.77.

Use of ICT Resources

The second subscale examined how students utilize various ICT tools in the context of learning mathematics. This section included items related to the use of:

- digital learning materials (e.g., PDF textbooks, video lectures),
- specialized mathematical applications and tools (e.g., GeoGebra, MATLAB),
- visualization software for conceptual understanding,
- platforms for searching additional academic resources,
- communication tools for peer collaboration and task sharing (e.g., messaging apps, online forums, social media).

Learning Strategies and Habits

The third subscale explored students' general learning strategies, with particular emphasis on the sequence and depth of content engagement. Key topics included whether students prefer to study theoretical concepts before solving practical tasks or vice versa, and the relative importance they place on using textbooks compared to their personal lecture notes. This subscale also showed acceptable reliability, with a Cronbach's alpha of 0.62.

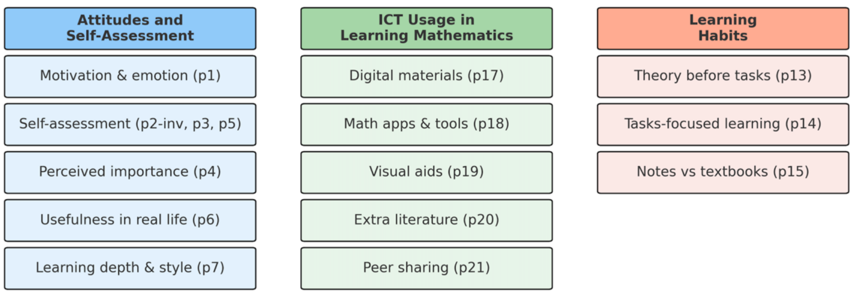

Figure 1. Schematic representation of the subscales utilized in the research instrument.

Data analysis

Descriptive statistics were calculated for all questionnaire items to summarize response patterns across the three subscales. Differences in students' attitudes, use of ICT resources, and learning strategies were examined in relation to gender, number of completed mathematics courses (first-year vs. third-year students), and type of secondary school completed (grammar school vs. vocational school). Given the ordinal nature of the data and the absence of normal distribution, the non-parametric Mann–Whitney U test was applied to assess statistically significant differences between groups. All data processing and statistical analyses were performed using Python (version 3.11).

RESULTS

Attitudes and Self-Assessment in Learning Mathematics

Descriptive statistics for the attitude scale are presented in Table 1**.** The highest mean score was recorded for *Perceived Importance* (p4, M = 4.20, SD = 0.93), indicating that students generally perceived mathematics as an important subject. This was closely followed by *Motivation & Emotion* (p1, M = 3.91) and *Learning Depth & Strategy*(p7, M = 3.84), suggesting a relatively strong engagement and strategic approach to learning mathematics.

In contrast, the lowest mean was observed for *Self-assessment* (p2, M = 2.89); however, this item was inversely coded, meaning that lower scores indicate higher self-assessment. The mode for this item was 2, further supporting the interpretation that many students positively evaluated their own mathematical abilities. Similarly, *Knowledge Evaluation*(p5, M = 3.73) and *Prior Knowledge* (p3, M = 3.51) showed moderately high scores, suggesting that students generally perceived themselves as reasonably familiar with and capable of evaluating mathematical content.

Table 1. Descriptive statistics for items measuring students' attitudes toward mathematics.

Question	Description	Mean	Std Dev	Mode
p1	Motivation & Emotion	3.91	1.1	5
p2	Self-assessment (inversely)	2.89	1.19	2
p3	Prior knowledge	3.51	1.13	4
p4	Perceived Importance	4.20	0.93	5
p5	Knowledge Evaluation	3.73	0.97	4
p6	Usefulness in Real Life	3.01	1.19	4
p7	Learning Depth & Strategy	3.84	1.13	5

To further explore students' attitudes toward mathematics, additional analyses were conducted to examine differences based on key background factors: gender, number of completed mathematics courses, type of secondary school previously completed, and year of study. Statistically significant differences were identified for several items, as shown in Table 2.

Table 2. Results of Mann–Whitney U tests for differences in attitude items by students' background characteristics.

Question	Factor	Group 1	Group 2	Mean 1	Mean 2	U-value	p-value
p3	Type of school	Grammar	Vocational	3.64	3.24	9550	0.006
p1	Course	More	One	4.04	3.75	10126	0.0433
p5	Course	More	One	3.85	3.58	10398	0.0139

Statistically significant differences were observed in several attitudinal items based on students' background characteristics. Students who had completed more than one mathematics course reported higher motivation and emotional engagement (*p1*, M = 4.04) compared to those who had completed only one course (M = 3.75; $p = 0.0433$). Similarly, they rated mathematical knowledge (*p5*) more positively (M = 3.85 vs. 3.58; $p = 0.0139$).

In addition, a significant difference was found in perceived prior knowledge (*p3*) based on the type of secondary school completed. Students from grammar schools reported higher levels of prior knowledge (M = 3.64) than those from vocational schools (M = 3.24; $p = 0.006$), suggesting a potential gap in foundational mathematical preparation between these groups.

Use of ICT Resources

In the second part of the study, students were asked to evaluate the extent to which they use various ICT resources in learning mathematics (Table 3). Among the listed resources, students most strongly agreed with the statement related to *peer sharing of tasks via social media* (*p21*, M = 4.31, SD = 0.94), indicating that this is the most commonly used ICT-related activity. *Digital materials*such as e-textbooks and lecture notes (*p17*) were also frequently used (M = 3.88), with the mode value of 5 suggesting high agreement across responses.

In contrast, the least utilized resources were *mathematics-specific applications or software* (*p18*, M = 2.77) and *visualization tools for mathematical content* (*p19*, M = 2.74), both with a mode of 2, indicating general disagreement or neutrality. Searching for additional literature (*p20*) received a moderate score (M = 3.14), suggesting occasional but not widespread use.

Table 3. Students' use of ICT resources in learning mathematics.

Question	Description	Mean	Std Dev	Mode
p17	Digital materials	3.88	1.07	5
p18	Math apps/software	2.77	1.28	2
p19	Visualization of math content	2.74	1.14	2
p20	Finding additional literature	3.14	1.26	2
p21	Peer sharing tasks via social media	4.31	0.94	5

To examine whether students' use of ICT resources in learning mathematics differs across background factors, Mann–Whitney U tests were conducted. Statistically significant differences were identified for two items, as shown in Table 4.

Female students reported significantly higher use of *peer sharing of tasks via social media* (*p21*) compared to male students (M = 4.56 vs. 4.21; *p* = 0.0028), indicating a greater tendency among female students to engage in collaborative learning through digital platforms.

In addition, a significant difference was observed in *searching for additional literature* (*p20*) based on the number of mathematics courses completed. Students who had completed only one course reported higher usage of this resource (M = 3.41) compared to those who had completed multiple courses (M = 2.93; *p* = 0.0024).

Table 4.Statistically significant differences in students' use of ICT resources based on gender and number of completed mathematics courses.

Question	Factor	Group 1	Group 2	Mean 1	Mean 2	U-value	p-value
p21	Gender	F	M	4.56	4.21	9188	0.0028
p20	Course	More	One	2.93	3.41	7033.5	0.0024

Learning Strategies and Habits

In the third part of the study, students were asked about their preferred learning strategies when studying mathematics, with a particular focus on whether they tend to engage with theoretical material before solving problems. Descriptive statistics for these items are presented in Table 5.

The results indicate that students predominantly learn through solving tasks rather than starting with theoretical content. The item *"Learning through tasks"* (*p14*) received a relatively high mean score (M = 3.76), suggesting that many students rely on a practice-oriented approach. Similarly, *"Using lecture notes over textbooks"* (*p15*) was rated highly (M = 3.86, mode = 5), indicating a preference for condensed or instructor-guided materials.

In contrast, the item *"Studying theory before attempting tasks"* (*p13*) received the lowest mean score (M = 2.48, mode = 2), showing that most students do not follow a theory-first strategy when learning mathematics. These results point to a more pragmatic and task-driven learning habit among the participants.

Table 5. Students' learning strategies in mathematics.

Question	Description	Mean	Std Dev	Mode
p13	Theory before tasks	2.48	1.28	2
p14	Learning through tasks	3.76	1.21	4
p15	Notes over textbooks	3.86	1.17	5

Further analysis revealed statistically significant differences across subgroups. Regarding *p13*, students enrolled in 2021 reported a significantly higher preference for theory-first learning compared to those from the 2020 cohort ($p = 0.0002$). Similarly, students who completed grammar school gave higher ratings than those from vocational schools ($p = 0.0052$), suggesting that prior educational background may influence learning approach.

For *p15*, students from the 2020 cohort reported a stronger preference for lecture notes over textbooks compared to the 2021 cohort ($p = 0.0123$). In addition, students who attended more course rated this item significantly higher than those who attended one course (M = 4.11 vs. 3.53; $p = 0.0001$), indicating potential differences in instructional design or course culture that affect study habits.

DISCUSSION AND CONCLUSION

Attitudes and Self-Assessment in Learning Mathematics

The results of this study indicate that engineering students generally exhibit a positive attitude toward mathematics, highlighting both the importance of the subject and their own motivation to learn it. Students' perception of the relevance of mathematics to their engineering studies and future careers appears to be a key factor shaping their engagement. As noted by previous research, students who understand the practical applications of mathematics within engineering contexts are more likely to appreciate and actively engage with mathematical content (Parsons, 2006; Zavala & Dominguez, 2016; Gold, 2015). Conversely, a lack of understanding of how mathematical concepts apply to real-world engineering problems can hinder student engagement (Panaoura et al., 2024).

Our findings suggest that engineering students not only demonstrate positive attitudes, but also hold a high level of confidence in their own mathematical knowledge. Many participants rated their abilities favorably and perceived themselves as competent in mathematics. This combination of interest, appreciation of relevance, and self-confidence represents an encouraging profile for future engineers. As highlighted in the literature, such positive attitudes and strong self-efficacy beliefs are associated with better academic outcomes, regardless of students' prior qualifications (Parsons, 2006; Panaoura et al., 2024; Morán-Soto & Benson, 2018). Furthermore, self-efficacy has been shown to influence students' willingness to engage with more demanding mathematical tasks and to seek support when encountering difficulties (Morán-Soto & Benson, 2018).

Although the overall attitudes were positive, further analysis revealed certain differences based on students' educational backgrounds. Those who had completed grammar school reported significantly higher self-assessments of their mathematical knowledge compared to students from vocational secondary schools. In addition, students who had completed more mathematics courses at the university level not only perceived their knowledge more positively, but also reported higher motivation and a more favorable attitude toward the subject. These findings suggest that continued exposure to mathematics through university coursework may further enhance students' appreciation and confidence, reinforcing the value of effective higher education instruction in fostering positive dispositions toward mathematics.

Use of ICT Resources

The results of this study show that engineering students most commonly use information and communication technologies (ICT) to access and utilize electronic materials for learning mathematics. This is partly due to the structure of university mathematics courses, where teaching content is often distributed in digital formats. The use of e-learning platforms and internet resources, including social networking mediums, has become an integral part of traditional instruction, supporting students in understanding mathematical concepts and solving problems more effectively (Mohd & Maat, 2013).

Another prominent function of ICT in this context is communication. Students frequently rely on ICT to collaborate and exchange materials with peers, often through informal channels that exclude teaching staff. These forms of communication, such as chat groups and messaging applications, serve as important spaces for peer-to-peer learning and the distribution of problem-solving strategies. The study also found that female students tend to use ICT slightly more often than their male peers, which may reflect differences in communication preferences or learning strategies.

Despite their regular engagement with digital technologies in everyday life, students reported relatively low levels of usage of mathematical tools and visualization software for learning purposes. This suggests an opportunity for improvement within formal instruction. While general access to digital content is widespread, many students are not familiar with or do not actively engage with mathematical applications, simulation environments, or platforms that enable the visualization of abstract concepts. Specific tools such as virtual laboratories, simulation software, and data analysis applications can help students connect mathematics to real-world engineering problems (Rasteiro et al., 2023). Visualization, in particular, is recognized as a powerful resource in supporting conceptual understanding (Cao et al., 2022), yet its pedagogical potential remains underused.

Given these findings, there is a clear need to guide students more intentionally in using specialized ICT resources for learning mathematics. Although they are generally technologically literate, students may not independently seek out tools that could enhance their learning. As previous research has suggested, even students who are immersed in technology in their daily lives do not always use it strategically for academic purposes, particularly in mathematics education (Saadati et al., 2014). Integrating relevant tools into regular instruction and actively encouraging their use may significantly contribute to more effective and engaged mathematical learning.

Learning Strategies and Habits

The findings of this study suggest that when learning mathematical content, engineering students tend to prioritize solving tasks over engaging with theoretical material. While this pragmatic approach may reflect students' desire for efficiency or practical relevance, it also highlights an opportunity for pedagogical improvement. Previous studies have emphasized the benefits of building a strong conceptual and theoretical foundation prior to tackling procedural tasks. For example, administering theoretical assessments before practical ones has been shown to enhance students' performance on applied tasks, as it helps consolidate their understanding of mathematical principles (Zeidmane and Atslega, 2014). A clear comprehension of fundamental laws supports more effective problem-solving and encourages deeper learning (Rooch et al., 2016).

This issue becomes particularly relevant in the context of the growing influence of artificial intelligence and digital automation. As computational tools increasingly take over routine and procedural tasks, students are expected to develop higher-order thinking and conceptual understanding that go beyond algorithmic execution. Emphasizing conceptual learning through well-structured instructional approaches and the integration of appropriate technologies can help students achieve a more meaningful grasp of mathematical ideas. Aligning theoretical instruction with practical applications, and presenting both in a way that emphasizes their interdependence, may enhance students' motivation and lead to more sustained engagement (Rooch et al., 2016).

Another important result concerns students' preferences for learning materials. Participants in this study expressed a strong inclination toward relying on their own lecture notes rather than using formal textbooks. This preference was more prominent among students in higher academic years, which suggests that experience in academic settings contributes to the development of personalized strategies that students perceive as more effective. These findings raise important questions regarding the adequacy and relevance of existing textbooks in higher mathematics education. More precisely, they point to the need for modernizing learning resources that serve as replacements for traditional textbooks (Anastasakis and Lerman, 2022).

Engineering students often supplement their learning using a wide array of tools such as online videos, virtual learning platforms, and peer discussions. These resources are often more accessible and more closely aligned with students' learning habits than conventional printed materials. In particular, the use of modern educational technologies, including interactive simulations, computer algebra systems, and dynamic visualization tools, enables students to explore mathematical concepts in more engaging and flexible ways. Such tools create learning environments that support experimentation, real-time feedback, and intuitive understanding, and may offer considerable pedagogical advantages compared to static content (Rasteiro et al., 2023). Enhancing the availability and integration of these resources into regular instruction could contribute to a more effective and personalized learning experience in mathematics education for future engineers.

In conclusion, the findings indicate that engineering students generally hold positive attitudes toward mathematics and confidence in their abilities, particularly those with stronger academic backgrounds. Digital technologies are widely used for accessing materials and collaborating with peers, while the use of advanced mathematical software and visualization tools remains limited. This points to the need for more purposeful integration of such tools and for a balanced approach that connects theory and practice to foster conceptual and critical thinking. Although the study is limited by its sample size and scope, the results suggest that future research should explore how artificial intelligence and adaptive technologies can further enhance mathematics learning in engineering education.

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DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

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