



A STUDY OF ESTONIAN HIGH SCHOOL STUDENTS' VIEWS ON LEARNING MATHEMATICS AND THE INTEGRATION OF DIGITAL TOOLS IN DISTANCE LEARNING¹

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Abstract: The COVID-19 pandemic has transformed the education landscape, with distance learning and digital tools becoming increasingly essential. This shift has presented both opportunities and challenges for educators and students. We examine the intersection between distance learning and digital tools in modern education, focusing on Estonian high school students' views on learning mathematics during the pandemic compared to the pre-pandemic period, and compare learning in classroom situations to distance learning. In 2021, we conducted online interviews with 30 12th-grade students who had participated in the online course offered by the university to prepare for the state mathematics exam. Given that the Estonian education system provides significant autonomy to teachers in selecting their teaching materials and methods, we explore the benefits and challenges of distance learning and the use of digital tools such as online platforms, video conferencing software, and educational apps to support student learning. The study found that teachers did not increase their use of specific ICT tools for teaching mathematics, but instead, relied on established teaching methodologies. Furthermore, the survey showed that learners expect an online course to be rich in video material and real-time meetings, so that they can get prompt feedback on questions and problems that arise. While digital tools have opened up new possibilities for distance learning, there must be a balance between technological innovation and human connection to create effective and meaningful learning experiences.

Key words: Distance learning, digital tools, mathematics

1. Introduction

There is a substantial history of research on distance learning, suggesting its comparable efficacy to traditional in-person learning (Borba & Villarreal, 2005; Lee & Figueroa, 2012; Means et al., 2013). However, success depends on good preparation.

The COVID-19 pandemic has triggered a paradigm shift in education, compelling the integration of distance learning and digital tools (Hodges et al., 2020). In the 2019/2020 school year, with insufficient time for proper online learning preparation, both positive and negative outcomes were evident (Crawford et al., 2020). Educators have emphasised the necessity for additional preparation time when taking on the role of facilitator in computer-assisted lessons (Prodromou et al., 2015). This transformation has not only reshaped traditional educational models but has also presented new opportunities and challenges worldwide (UNESCO, 2020). Progressing into the 2020/2021 school year, it became apparent who adapted well and who struggled.

On March 12, 2020, the Estonian government closed schools (Ministry of Education and Research) coinciding with the World Health Organization's declaration of COVID-19 as a global pandemic. This forced students into home learning for an indefinite period. The question arose: Why did some

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students express contentment with this new learning environment in terms of efficiency, while others argued that traditional classrooms were more favourable (Arnd-Caddigan, 2015, Selwyn, 2016)?

The efficiency of online learning depends on various factors, with one crucial aspect being how well teachers can use e-learning tools. Even in Estonia, known for its digital skills, challenges arose (Põldoja, 2020), attempting to pioneer technology in education faced multiple challenges in the new situation.

In the TALIS (The Teaching and Learning International Survey) 2018 study, 19.2% of Estonian teachers indicated a need for training in essential ICT skills for teaching. This percentage is higher than the OECD average (17.7%). However, the percentage of Estonian teachers participating in professional development activities that include training in essential ICT skills for teaching was even higher, at 74.1%, compared to the OECD average of 64.4%. (Taimalu et al., 2018)

According to Mailizar et al. (2020), students' possibilities, skills, and willingness to use e-learning resources constitute one of the main bottlenecks of distance learning in the opinion of teachers. But how do students themselves describe their learning experiences and motivation during the compulsory distance learning period? We focus on the learning and teaching of mathematics due to the special characteristics, differences, and complexity of this subject compared to others in a distance learning situation (Frid, 2002).

This paper investigates the impact of the pandemic on the learning experiences of Estonian high school students in mathematics, comparing the current situation to pre-pandemic times. The focus is on exploring the connection between online learning and digital tools in today's education (Trouche & Drijvers, 2010). By examining the experiences of Estonian students, we aim to contribute valuable information to our understanding of how digital tools, online learning, and maths education are connected. The insights from this study could be beneficial for educators worldwide, helping them determine the best ways to use digital tools for teaching maths, especially during challenging times and in the future.

Our primary goal is to investigate how the balance between technology and human connection has been maintained during distance learning and how this impacts the effectiveness and meaningfulness of learning experiences in the final year of upper secondary school in the context of learning mathematics during compulsory distance education. To achieve this, we pose two research questions:

1. What are the views of Estonian high school students on learning mathematics during the COVID-19 pandemic (distance learning) compared to the pre-pandemic (learning in traditional classroom situations) period?
2. What are the expectations of learners regarding the content and format of online courses, particularly in terms of video material, real-time meetings, and prompt feedback on questions and problems?

2. Methodology

Over the past four years, Estonian students have had the opportunity to engage in free entirely online mathematics courses.

In the spring of 2021, the Ministry of Education and Research provided an opportunity for 12th-grade students to enrol in complimentary distance learning courses at universities to aid in their preparation for state examinations. A total of 1,622 students participated in the course offered by the University of Tartu. In Estonian upper secondary schools (grades 10-12), students can opt for either a narrow or extensive mathematics education. Of the participants, 947 were enrolled in the extensive mathematics course, while 675 chose the narrow mathematics course. To provide context, the mathematics examination in the spring of 2021 involved 6,666 students in Estonia, with 4,246 opting for the extensive mathematics exam and 2,420 taking the narrow mathematics exam.

The courses provided by the University of Tartu were conducted in the university's Moodle environment, with separate courses created for students preparing for narrow and extensive

mathematics exams. We divided high school mathematics topics into ten modules: expressions and equations; inequalities and word problems; trigonometry and solving triangles; vectors in the plane and equation of a line; exponential and logarithmic functions; sequences and probability; derivative and its applications; integral and plane geometry; solid geometry; review of all topics. Each module contained PDF files with relevant exercises and formula sheets, along with instructional videos. For practice, students had quizzes on fundamental concepts (multiple-choice) and STACK tests for solving problems (see Figure 1).

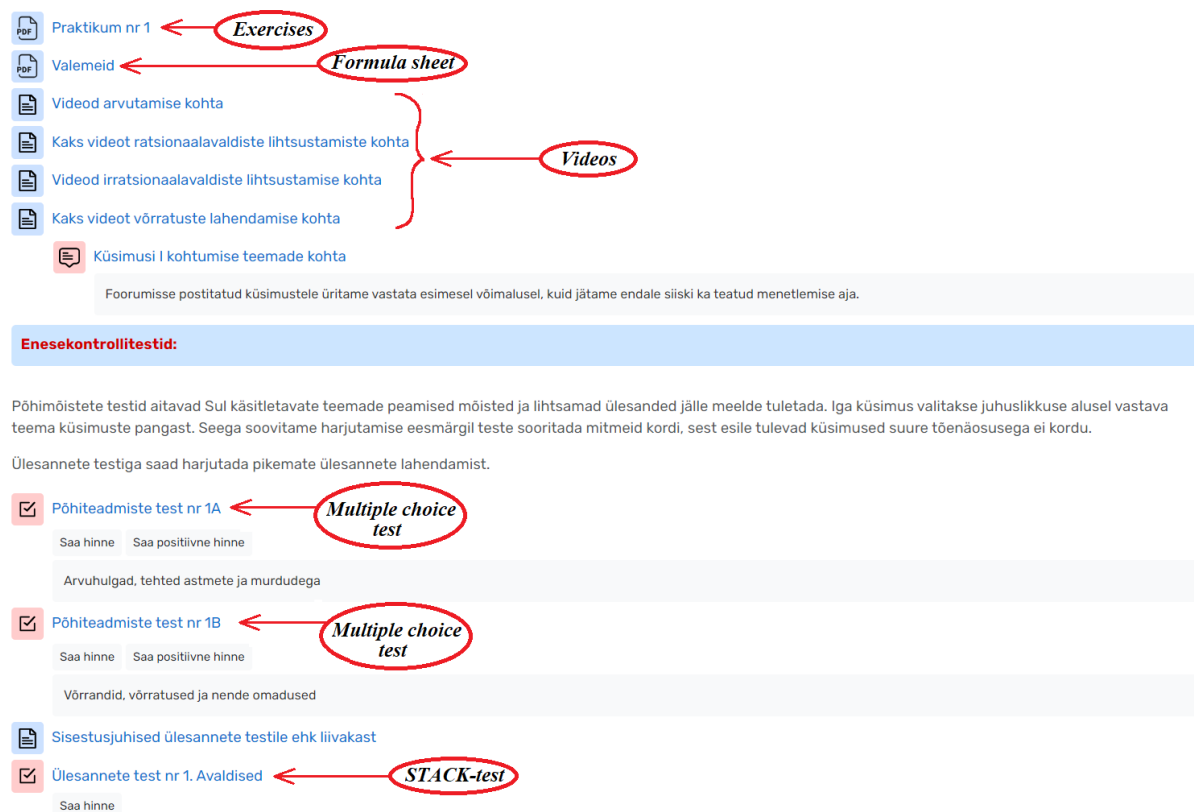


Figure1. The student view of the Moodle environment

Once a week, Zoom webinars were held as online classes/consultations, with two university instructors present: one who explained problem solutions and formatting, and another who answered students' questions submitted in the chat window (microphone use was disabled for students because there were hundreds of participants).

After the course concluded on May 21, 2021, participants were invited to share their experiences with distance learning through the University Study Information System. Interested students were requested to complete a Google Forms questionnaire, providing details such as their name, email address, the selected mathematics path (narrow or extensive), and consent for an interview. Out of the 55 students who responded, 30 agreed to be interviewed. This group included 14 from the extensive maths course and 16 from the narrow maths course, with 24 female students and 6 male students. Online interviews were conducted online from May 25 to June 11, 2021, using a tool called Big Blue Button. In the interviews, learners were asked about their experiences with learning mathematics more broadly, how distance learning has affected them, and what they expect from subject-specific online courses (see Annex). Students agreed to have their interviews recorded.

Following the collection of interview data, the recorded interviews were transcribed into 30 text documents, capturing both verbal and non-verbal cues. Two researchers independently encoded the interviews, employing inductive qualitative content analysis as the research method to find patterns and themes in what the students said. The encoding process was undertaken to categorise the rich information obtained from participants. Upon reviewing the transcriptions, recurring themes related to

challenges in adapting to online learning (concentration), independence, similarities in teaching methods and the impact of limited teacher-student interaction emerged. These themes provided initial insights into the participants' experiences.

The research adhered to ethical guidelines, and participants provided informed consent for interviews and data usage. To ensure confidentiality, all identifiable information was anonymized during data analysis. Data was securely stored on password-protected servers, accessible only to the research team, to safeguard participant privacy and comply with data protection regulations.

3. Results

Upon analysing the data gathered from our study, we uncovered noteworthy findings that offer insights into the intersection of distance learning, digital tools, and mathematics education among Estonian high school students during the COVID-19 pandemic.

The in-depth interviews revealed varying degrees of emphasis on different themes among the participants. Notably, themes such as Time Planning and Solitude emerged as significant topics of discussion, with respective frequencies of 15 and 15 mentions. Additionally, Video Lesson and Geogebra were highlighted in 13 and 14 instances, indicating the importance of technology use in the participants' experiences. Furthermore, Similarities and Concentration/Attention Diffusion were noted 10 and 5 times, respectively, reflecting shared experiences and challenges faced by the participants. The themes of Individuality and Independence were also discussed, with 8 and 5 mentions, contributing to a comprehensive understanding of the participants' perspectives.

3.1 What are the views of Estonian high school students on learning mathematics during the COVID-19 pandemic (distance learning) compared to the pre-pandemic (learning in traditional classroom situations) period?

Contrary to our initial expectations and the prevalent global reliance on digital solutions, the study revealed that many educators in Estonia did not demonstrate a significant increase in the use of specific Information and Communication Technology (ICT) tools for teaching mathematics. Out of the interviewees, for example, 10 students stated that in their opinion, there was no change in teachers' teaching styles; instead of using a chalkboard, they now used a screen. Instead, they adhered to established teaching methodologies, indicating a cautious approach to integrating new technologies into their pedagogical practices. One student expressed surprise, saying, *"I expected more online platforms and interactive tools, but most of our teachers stuck to the traditional methods. It was surprising because I thought distance learning would bring about a complete shift to digital tools."*

Our findings highlighted a prevalent reliance on traditional teaching methods, suggesting a degree of continuity in instructional approaches despite the shift to distance learning. This observation implies that while the educational landscape underwent significant changes, certain established practices remained resilient in the face of unprecedented challenges. One student appreciated this continuity, stating, *"I appreciated that some things stayed the same. It was comforting to have the familiar structure of lessons, even though we were learning from home. I think it helped with the transition."*

In the interviews, it was mentioned several times (10) that there was no change in teaching style by teachers: sample problems were still solved first, and then students were expected to solve problems on their own. The only difference noted was that while in the classroom the chalkboard might be distant, the computer screen serving as a board was close by.

As a positive difference, it was mentioned (15 times) that learners largely had control over their own time. However, as distracting factors (7 students), in distance learning, the home environment was cited: family members also being at home, etc.

Additionally, self-assessment opportunities were integrated to the course, allowing students to gauge their fundamental knowledge through self-administered assessments. As an innovative addition, students were able to practise problem-solving through STACK tests. The special feature of the latter is that the solution idea for the tasks is programmed in, thus giving hints as to how to proceed.

However, it was often pointed out that solving tasks on the computer is tedious and time-consuming, and therefore it was abandoned as course continued. As one student pointed out “*I generally don't enjoy doing tasks on the computer either, but in maths, finding and formatting different symbols is even more troublesome than in any other subject. Time consumption is too inclined towards formalisation rather than substantive resolution.*”

For example, completing the simplification of expressions STACK test required students to input variables in a manner unfamiliar to them (different from handwriting) (see Figure 2).

Küsimus 1
 Pole veel vastatud
 Võimalik punktisumma: 1.00
 Märjastatud küsimus

Sisestusjuhised

Ülesanne. Lihtsustage avaldis $\frac{\sqrt{k}}{k - \sqrt{k}} - \frac{2}{k - 1}$ ja arvutage selle väärtus, kui $k = \left(\frac{1}{16}\right)^{-\frac{1}{2}}$.

Lahendus. Esitage murru $\frac{\sqrt{k}}{k - \sqrt{k}}$ nimetaja $k - \sqrt{k}$ kujul $\sqrt{k}(\sqrt{k} - 1)$. Millist võtet/valemit siin kasutasime?

(No answer given) ▾

Seda murdu saab taandada. Mis on lugeja ja nimetaja suurim ühine tegur? (Avaldise $\sqrt{k}$ saate kirjutada kujul `sqrt(k)`.)

Esitage murru $\frac{2}{k - 1}$ nimetaja $k - 1$ kujul $(\sqrt{k} - 1)(\sqrt{k} + 1)$. Millist võtet/valemit siin kasutasime?

(No answer given) ▾

Murdude $\frac{1}{\sqrt{k} - 1}$ ja $\frac{2}{(\sqrt{k} - 1)(\sqrt{k} + 1)}$ ühine nimetaja on (leidke vähim ühiskordne)

Esimese murru laiendaja on

Teise murru laiendaja on

Lihtsustage algne avaldis ja esitage vastus ühe murruna nii, et nimetajas ei oleks irratsionaalsust

Lihtsustame nüüd arvu $k = \left(\frac{1}{16}\right)^{-\frac{1}{2}}$. Mida tähendab negatiivne astendaja?

(No answer given) ▾

Figure 2. Example of a STACK exercise

The latest feedback regarding this course and the mathematics instruction has been highly favourable. Students appreciated the flexibility of independently working through course materials prior to webinars and problem-solving sessions. They expressed particular satisfaction with the option to revisit webinars and other video resources as needed, allowing them to tailor their learning experience to their own pace.

3.2 What are the expectations of learners regarding the content and format of online courses, particularly in terms of video material, real-time meetings, and prompt feedback on questions and problems?

Responding to diverse feedback the mentioned modules included textual materials featuring exercises with corresponding answers and formula reference sheets. Furthermore, illustrative video presentations offering step-by-step explanations of problem-solving strategies at various difficulty levels were provided.

Turning to the survey results, participants' expectations for online mathematics courses during the pandemic became evident. A key finding was the preference for courses to incorporate rich video materials and real-time meetings. Students expressed a desire for interactive elements that facilitate immediate engagement, enabling prompt feedback on questions and challenges encountered during the learning process. Each module provided a forum for students to seek clarifications and pose questions. Beyond these foundational elements, weekly live webinars were conducted, wherein supervising instructors solved problems and addressed student inquiries in real-time. These webinars were recorded and made accessible for review throughout the duration of the course. One student shared, *"I found the online courses more engaging when there were videos explaining concepts. It made it feel more like a regular class. And having real-time meetings helped because we could ask questions right away."*

The emphasis on real-time interactions and prompt feedback underscored the significance of timely support in the virtual learning environment. This finding highlights the importance of addressing students' queries and concerns promptly, contributing to a positive and effective online learning experience.

Collectively, these findings contribute to an understanding of the intricate dynamics between pedagogical approaches, technological integration, and student expectations in the context of Estonian high school students' experiences with mathematics education during the COVID-19 pandemic.

4. Conclusion

The study found that during distance-teaching teachers did not significantly increase their use of specific ICT tools for teaching mathematics, but instead, relied on established teaching methodologies. A third of the interviewees mentioned that there was no change in the teachers' teaching style and computer-based learning platforms were not introduced. Furthermore, the survey showed that learners expect an online course to be rich in video material and real-time meetings, so that they can get prompt feedback on questions and problems that arise. For courses with a large number of participants, it's important to have two teachers present during the online class: one who explains the topic and another who keeps an eye on the questions in the chat window and answers them when possible.

This study provides a nuanced exploration of the evolving dynamics within the landscape of mathematics education in Estonia amid the challenges posed by the COVID-19 pandemic. The findings offer critical insights that extend beyond the specific context, providing valuable considerations for educators, policymakers, and researchers navigating the intersection of distance learning, digital tools, and effective mathematics education.

While digital tools have undoubtedly expanded the possibilities for distance learning, a crucial finding emphasises the importance of maintaining a balance between technological innovation and human connection. The study suggests that, despite the opportunities afforded by digital platforms, traditional teaching methods persist in mathematics education in Estonia.

Building upon the insights derived from this study, an exploration into the perspectives of Estonian high school students on learning mathematics in the context of the COVID-19 pandemic reveals a comparison between their experiences during this period and the pre-pandemic era. These findings offer valuable insights into the nuanced ways in which students adapted to the challenges presented by the transition from traditional classroom settings to distance learning environments.

The research explored the views of high school students regarding the learning of mathematics amidst the pandemic, revealing a spectrum of opinions and experiences. The comparison between perspectives before and during the pandemic underscored the complex effects of the unprecedented circumstances on students' views of mathematical education. This analysis provided valuable insights into the adaptability of students and the effectiveness of various learning modalities, offering a nuanced understanding of the challenges and advantages associated with each approach.

Lastly, the research delved into the expectations of learners concerning the content and format of online courses, particularly emphasising key elements such as video material, real-time meetings, and prompt feedback. The identified preferences underscored the importance of interactive and engaging components in online education, signalling a desire for dynamic and responsive learning experiences.

In light of these research questions, it is evident that the COVID-19 pandemic has prompted a reevaluation of educational practices, particularly in the realm of mathematics instruction. The varied responses and expectations of high school students emphasise the need for a flexible and student-centric approach to education, with a careful consideration of technological tools and interactive elements that enhance the learning experience. As we move forward, these insights can inform educational policymakers, institutions, and educators in adapting and refining their approaches to meet the evolving needs and expectations of students in a rapidly changing educational landscape.

The insights derived from this study contribute to the growing body of knowledge on the interplay between technology and education. As the educational landscape continues to evolve, further research can delve into specific aspects such as the impact of teacher autonomy, cultural influences, and student expectations in shaping the integration of digital tools in mathematics education.

In conclusion, this study adds to the ongoing conversation about the future of education in the digital era. It offers insights for educators and policymakers, suggesting a careful approach to incorporating digital tools into mathematics education in Estonia. As we address the challenges of modern education, these findings highlight the ongoing significance of human interaction in learning.

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Annex - Interview Questions

How has your overall experience been with learning mathematics?

I Questions about the course

1. Why did you decide to take this course?
2. This course included webinars, recordings of which were available, videos, and homework assignments. How did you study in this course?
3. What could have been different about the course?
4. What changes would you make to improve such a course?

II Questions about learning mathematics in distance education

For quite some time, today's high school seniors have had to study remotely. Overall, how do you feel about learning remotely?

1. What are your experiences with learning mathematics during this period?
2. Did learning during the first period of distance education (last academic year) differ from distance learning this academic year?
3. Please describe how learning occurred during this period.
 - a. What were the advantages of such learning?
 - b. What were the difficulties of such learning?
4. When comparing learning mathematics during a period of distance education to traditional learning, what are the similarities and differences?