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Experiences in the education of mathematics during the digital curriculum from the perspective of high school students

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Abstract. Due to the COVID-19 epidemic, Hungarian schools had to switch to a digital curriculum for an extended period between 2019 and 2021. In this article, we report on the experiences regarding the education of mathematics during the digital curriculum in the light of the reinstated on-site education, all through the eyes of high school students. Distance education brought pedagogical renewal to the lives of many groups. Students were asked about the positives and negatives of this situation.

Key words and phrases: education, digital curriculum, student, teacher, platform, online, Hungarian mathematics teaching.

MSC Subject Classification: 97C90.

Introduction

The COVID-19 epidemic presented the teachers and students of high schools in our country with two challenges: first, in the academic year 2019/2020 (between 16/03/2020 and 2/06/2020), the schools had to switch to a digital curriculum, and then roughly two-thirds of the following academic year (between 11/10/2020 and 19/04/2021) had to be spent by high school students in distance education (UNESCO, 2022). Since then, the academic year 2021/2022 has also ended, which – despite prior fears – could be implemented entirely by on-site education. In our article about the first digital transition and the initial difficulties of online mathematics education (Máder et al., 2020), we reported how three teachers, instructors, and students, having different experiences at different levels of education, but having also the same enthusiasm and didactic research spirit, found the given period. Our goal was to help other teachers by sharing our experiences.

The purpose of this paper is to report on the experiences regarding the education of mathematics during the digital curriculum in the light of the reinstated on-site education, all through the eyes of high school students. With the questionnaire created to find out the opinions of the students, we sought answers to questions such as which of the platforms we used (and presented in the article mentioned above) were used by the students, how useful the respondents of the questionnaire found the online lessons and the digital toolkit, and how they consider now the quality and quantity of their work at that time, the level of knowledge they acquired then, as well as the positives and negatives of the situation.

The questionnaire

We started the online questionnaire survey in the last weeks of the academic year 2021/2022, and we tried sharing it in groups of social networking sites on the Internet to reach colleagues teaching mathematics. A total of 532 people filled out the questionnaire between 6 and 17 June 2022, of which 432 people were students of grades 10-12. During the evaluation, we primarily relied on the data of these responding students (hereinafter: students), since they had already been in high school education during the first transition, and they had studied in the digital curriculum for the longest time (the primary schools in the academic year 2020/2021 were closed only from 8 March 2021).

62% of the students study in secondary schools in Szeged, 17% in Kiskunhalas, 15% in Budapest, and the remaining 6% come from secondary schools in Kiskunfélegyháza, Debrecen, Győr, Baja, Kecskemét, and Csongrád. In terms of grades, 10th- and 11th-grade students predominate (Figure 1). The possible reason for this is that it could be more difficult for teachers to reach students who had already been preparing for the high school graduation exam.

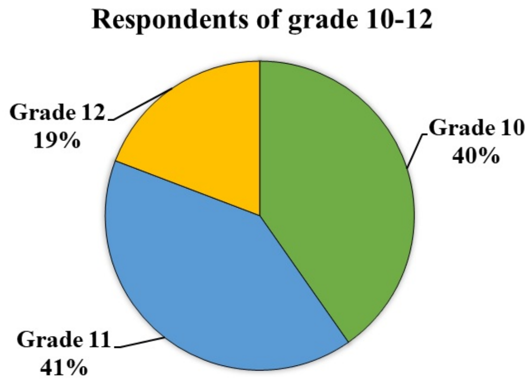

Figure 1. Distribution of the respondents

Figure 2 shows the type of school the respondents study in. More than half of the participants are four-year high school students, but a good number of students of six-year and 4+1-year courses were also represented.

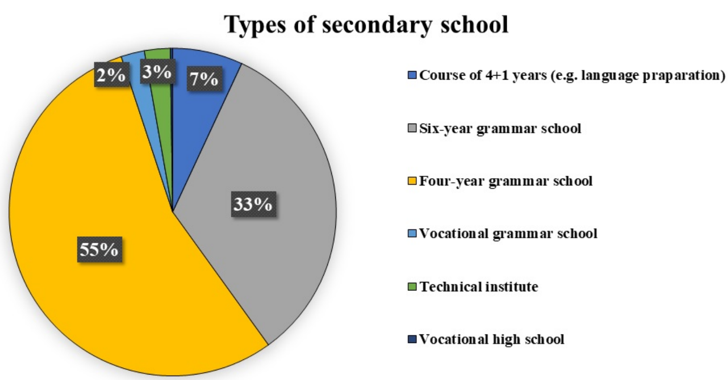

Figure 2. Types of secondary school

The platforms used

Many different platforms have come to the fore during the digital curriculum. These platforms, websites, and applications are rather diverse and suitable for performing different tasks. The ones used by teachers can be used to give lessons online, share support materials with students, practice, assign and submit tasks, or conduct assessments. When choosing the right tool, several aspects had to be considered, so it is not surprising that in different schools and classes, different teachers used different platforms and recommended them to students during or outside of maths classes. Within the questionnaire, we tried dividing the learning materials, platforms, and applications known by us into two groups. A separate question dealt with interfaces suitable for giving online lessons, supporting sharing the screen, uploading files, and commenting options, and within another question, it was possible to select the tools used for learning and practice.

Figure 3 illustrates the answers to the question "On which platform were the online mathematics lessons given under the digital curriculum?"

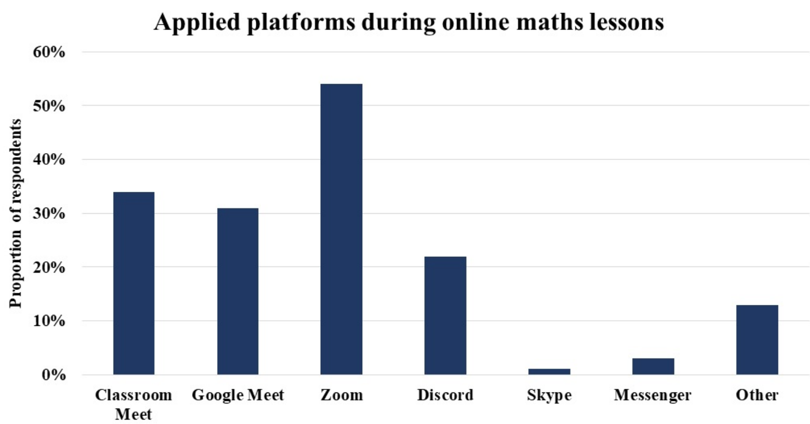

Figure 3. Applied platforms during online maths lessons

It is clear that half of the respondents (54%) used Zoom during mathematics lessons. The possible reason for this decision of the teachers is that the interface is fast, the sound is not delayed, and students who want to enter the "room" can be admitted even at the same time. 34% and 31% of students used a type of Meet. The reason for using Meet within Classroom could be that there is no time limit here, depending on the settings, students can join freely without permission, and the place of the lesson and assignments were thus not far from each other. The great advantage of Discord, nominated by 22%, is that it is already familiar to students who are comfortable in the world of computer games. Here, you can create different rooms (classrooms) in advance which any student with the appropriate right can enter at any time. The classrooms also have a chat wall where you can post learning materials. Students who marked the option “Other” could describe the platform they had used at the question at the end of the questionnaire. The answers include Teams, the Big Blue Button used in CooSpace (used by the students of the grammar school of the University of Szeged), the “lesson” uploaded by the teacher to YouTube, and Facebook live, and also, this option was marked by students who did not have online maths classes during the digital curriculum. You can also read about the characteristics of the platforms used during the digital curriculum in the paper “A survey on the e-learning platforms used during COVID-19” (Wang et al., 2020).

The grouped answers given to the question “Which platforms did you use to learn mathematics during the digital curriculum?” are illustrated in Figure 4. We have divided our answer choices (Akriel, GeoMatech, Google Jamboard, Kahoot!, Mateking, Okos Doboz, Redmenta, Quizizz, WorldWall, Other) into five groups: mathematical action technologies, conveyance technologies, online knowledge base, online assessment tools, other than listed (Santos-Trigo, 2020).

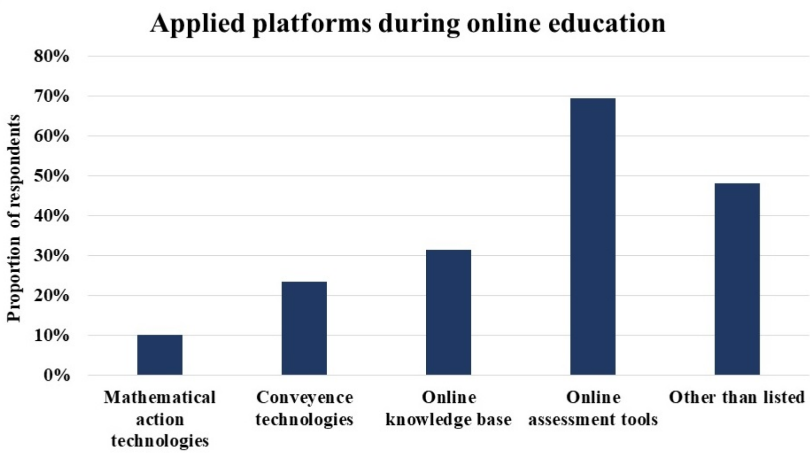

Figure 4. Applied platforms during online education

There is a much larger selection of auxiliary materials (programs of interactive training or practising, platforms for creating tasks and tests, digital learning material packages) than interfaces supporting screen sharing. Most of the elements of the (relatively larger) list given by us have already been used by at least 10% of the respondents. An exception is the intelligent algebra training program called Akriel (5%); as well as WordWall (4%), which is suitable for creating various (interactive whiteboard) tasks. Among the given options, most students chose Google Jamboard (23%). This interface could be useful for students not only in screen sharing online lessons but also during possible group work. Among the responses of those who marked the option "Other", the use of the GeoGebra program, the Wolfram Alpha and matekmindenkinek.hu webpages, YouTube videos, Classroom or CooSpace tasks, the Mathway and Photomath applications appeared, but several indicated that under the digital curriculum (apart from the online lesson and the description of the assigned tasks), no platform or device had been used. 59% of the respondents used more than one platform and 19% more than two.

Online lessons

The role and function of the classroom were beginning to transform even before the digital curriculum (Engelbrecht et al., 2020). The emergency brought this change even more to the fore. We have previously mentioned the topic of online lessons from the perspective of the platforms used. However, for schools and teachers, the problem was not only which method could be used to guarantee that the teacher and the students could see each other's work, but also the format of education that would replace the usual lessons under the digital education. Therefore, it became an important question to be answered how much of the usual amount of weekly lessons the teacher intends to keep in the form of online lessons, or instead, she/he only provides consultation opportunities for her/his students, or perhaps a combination of the two creates the new form of mathematics lessons. In many places, institutional or maintenance strategies and principles were created to coordinate the processes, so the form of lessons also received uniform regulations. The answers to "Under the digital curriculum, how much of the weekly mathematics lessons did the mathematics teacher give in the form of online lessons?" (1 – none; 10 – all) are shown in Figures 5 and 6.

190 of the students answered that their teacher had held all maths lessons during the digital education. This is 44% of respondents. According to 80% of the students, at least half of the weekly maths lessons were given by online presence. This data is also interesting because, if the teachers were thinking similarly in the case of the other subjects, the students had to spend half of their weekly hours (i.e., approximately 15 hours a week) sitting and listening in front of a computer,

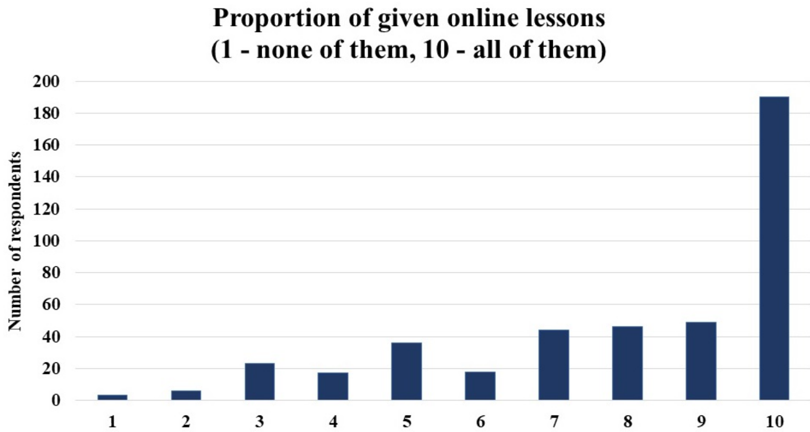

Figure 5. Proportion of given online lessons

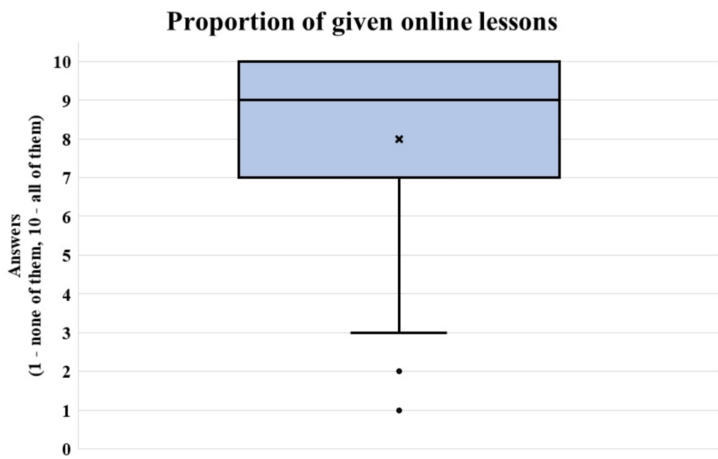

Figure 6. Box plot of the proportion of given online lessons

tablet, or phone. Moreover, the time spent studying, practising, and solving tasks outside of the lessons is added to that, too, which could often also be done in front of smart devices. In comparison, Drijvers et al. found that only 19% of German secondary school teachers, 44% of Flemish teachers and 66% of Dutch teachers used synchronous teaching formats more than once a week. On the base of the survey it was found that 47% of German teachers, 82% of Flemish teachers and 94% of Dutch used synchronous teaching formats about once a week (Drijvers et al., 2021).

We consider it an important question (especially since a significant part of the weekly mathematics lessons was not lost but transferred to the digital space) how useful the online mathematics lessons were considered by the students, as well as how involved they were in the lesson, or perhaps they were present as observers or spectators only. In the case of the question about the usefulness of the lessons ("If you participated in an online mathematics lesson under the digital curriculum, how useful did you feel it was?" (1 – not at all; 10 – completely)), the average was 6.73, the median was 7, and the standard deviation was 2.39. Regarding the question about the interactive nature of the lessons ("If you participated in an online mathematics lesson under the digital curriculum, how interactive did you feel it was?" (1 – not at all; 10 – completely)), the average was 6.10, the median was 6, and the standard deviation was 2.5.

Based on the answers to the questions about the proportion of lessons given, about their usefulness and their interactive nature, we examined whether there is a demonstrable relationship between them. Due to a large number of elements in the data, Pearson's correlation was used to examine the quality of the relationships. In the case of the examined pairs, we found a significant relationship; a weak positive relationship was found in the case of the pairs "proportion of lessons given – usefulness of lessons" and "proportion of lessons given – interactive nature of lessons", and a stronger than average positive relationship was found in the case of "usefulness of lessons – interactive nature of lessons". The p-value and the Pearson correlation coefficient for each case are shown in Table 1. Therefore, the strongest relationship was observed in the case of "usefulness of lessons – interactive nature of lessons". This result is in agreement with Lear et al.'s (2010) claim that interactions with teachers and peers help online learners to develop activity and engagement. Interactivity and a sense of community lead to high quality instruction and more effective learning outcomes. In addition, through interaction, students become more engaged, which enhances a sense of community and further improves engagement. However, it should be noted that the variables or the linear relationship may be influenced by other factors.

proportion of lessons given – usefulness of lessons	proportion of lessons given – interactive nature of lessons	usefulness of lessons – interactive nature of lessons
$p = 0{,}02078$ $r = 0{,}1112$	$p = 0{,}0001416$ $r = 0{,}1821$	$p = 2{,}2 \cdot 10^{-6}$ $r = 0{,}6251$

Table 1. The p-value and the Pearson correlation coefficient

Tasks of the students

In addition to being present in the online lessons, the students were able to encounter many types of activities which either aimed at extracurricular practice and deepening of their knowledge, or were used to check the work done by the students. We were also interested in the frequency with which each activity appeared during the learning of mathematics under the digital curriculum. The answers are shown in Figure 7.

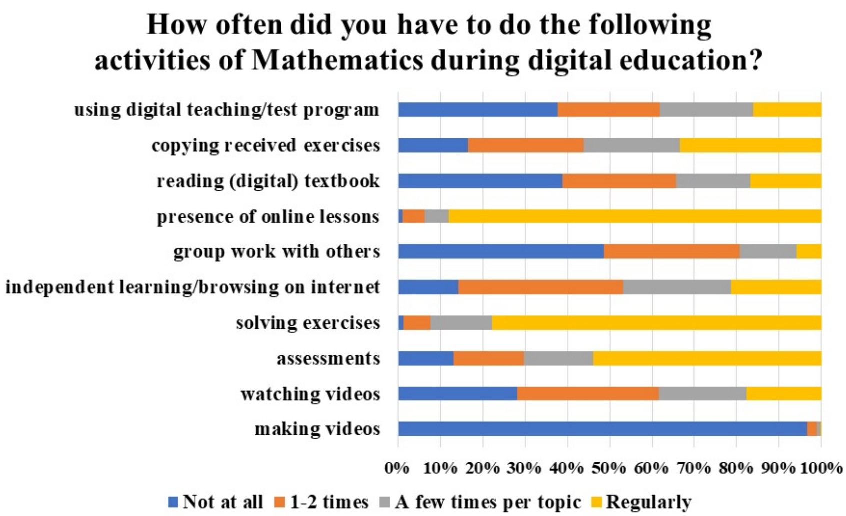

Figure 7. Activities during the learning of mathematics under the digital curriculum

So, according to the respondents, the activity they performed most often (after attending online lessons) was solving practical tasks and preparing assignments to be submitted; video editing came to the fore relatively rarely. In this difficult situation, when the students were far from their classmates and friends, it is particularly interesting that almost half of the respondents (48.6%) were never given a task that they should have solved not alone but in group work with others.

Another important question regarding the work done at home is the extent to which it built the student's knowledge and competencies related to mathematics indeed, since it cannot be guaranteed what kind of aid or help the solver will use for the task, and the identity of the solver cannot be guaranteed, either. Taking all of this into consideration, it is particularly interesting to what extent the students admit that they took this period and the work set for them seriously, as well as how confident they feel regarding their knowledge of mathematics compared to what they had experienced during on-site lessons.

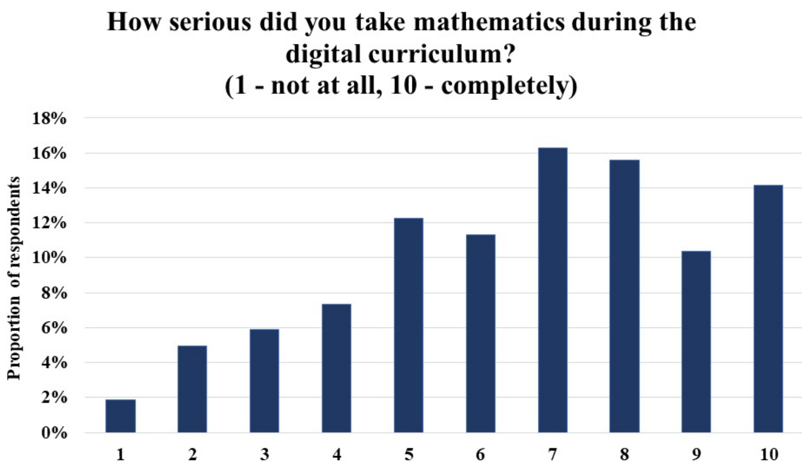

Figure 8. The perception of the students' fair work

Regarding the perception of fair work (Figures 8 and 9), the students gave mixed, although rather positive answers (average: 6.66; median: 7; standard deviation: 2.43). In contrast, they are not completely satisfied with the knowledge level assumed by themselves (Figures 10 and 11). The average of the answers to this question was 4.88, the median was 5, and the standard deviation was 2.57.

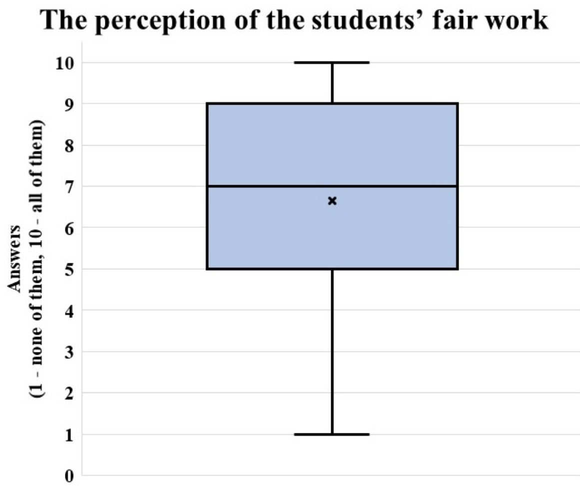

Figure 9. The box plot of the perception of the students' fair work

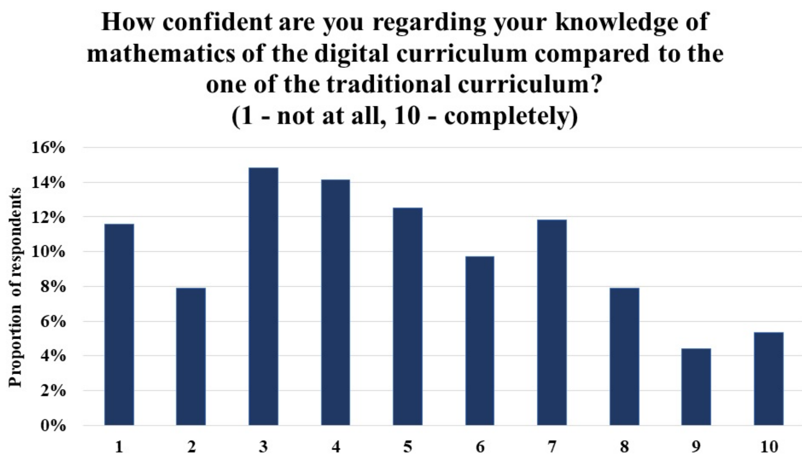

Figure 10. The perception of the students' knowledge level

Using Pearson's correlation, we also found a highly significant relationship between the degree of seriousness of the work and the assumed acquired knowledge ($p = 2,2 \cdot 10^{-6}$). The value of the correlation coefficient ($r = 0,5727$) indicates a stronger-than-average positive relationship.

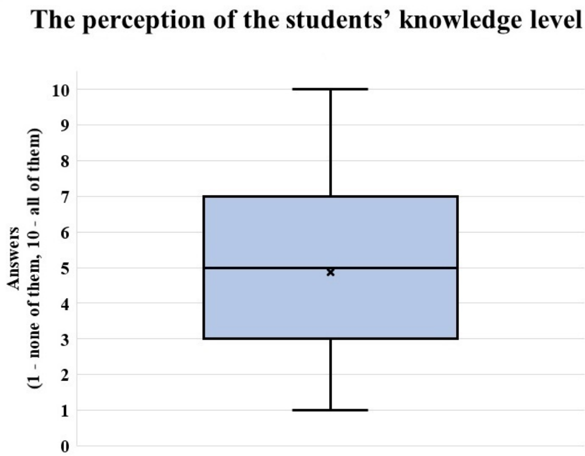

Figure 11. The box plot of the perception of the students' knowledge level

Assessments

The degree of honesty was not only important in the case of the time and quality of practice. The proper design of the assessments of knowledge was also a crucial issue. The teachers not only had to guarantee the credibility of the assessment but also to prevent possible frauds or filter them out. At the beginning of digital education, an important question to be answered was how the teachers could transfer the usual assessments to the virtual space, and how much the established system should be changed. In addition to ensuring authenticity, it was unavoidable to consider how to control the time and energy spent on correcting tests, as well as how compatible the prepared measuring instrument is with the requirements of the teacher and the graduation.

The latter is particularly important, since the current graduation system is not necessarily online compatible. This fact is reflected in the answers to the question about the form of the assessments used. Figure 12 clearly shows that most respondents (90%) usually gave an account of their current knowledge in the extended, online form of traditional test writing. The other methods were used in less than a quarter cases of the respondents.

The answers to the question "To what extent did you find the assessments realistic (the material having been taught was asked) in mathematics during the

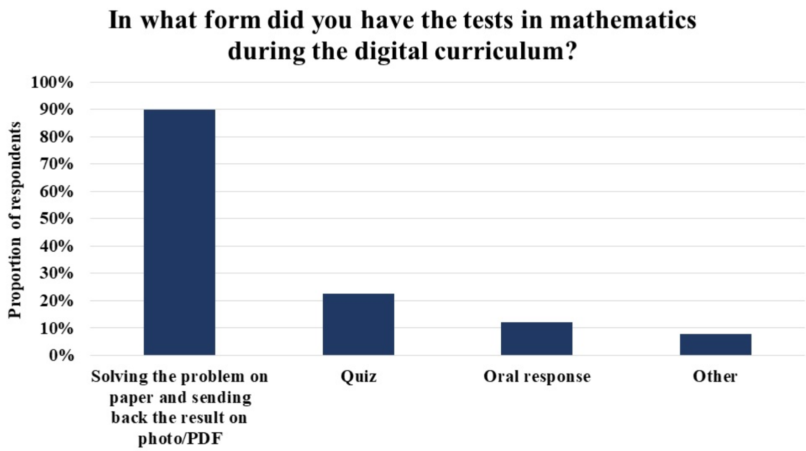

Figure 12. The form of the tests during the digital curriculum

digital education?" (1 – not at all; 10 – completely) had an average of 7.41 (median: 8; standard deviation: 2.42), whereas the answers to "How fair did you find the assessments in mathematics during the digital education?" (1 – not at all; 10 – completely) had an average of 7.42 (median: 8; standard deviation: 2.40).

Using Pearson's correlation, we also found a highly significant relationship between the reasonability and fairness of the assessments ($p = 2,2 \cdot 10^{-6}$). The value of the correlation coefficient ($r = 0,7393$) indicates a strong positive relationship.

Back to school

Although after the multiple transitions to the digital curriculum and the functional maintenance of the new system, everyone (both teachers and students) returned to school with joy, this situation also contained difficulties. As we have seen previously, most students reported that they did not feel confident with their mathematical knowledge acquired under the digital curriculum, and not everyone was prepared to plan and organize their daily routine and learning habits for a long period of time, which had been transformed by the online education.

Based on students' answers, only 27% of them did not change their time spent studying mathematics after switching from the traditional curriculum to a digital one, while the remaining 73% reported an increase or decrease in approximately half-half (35% and 38%) of the study time. With the return of on-site education, 26% of the students did not change their average study time developed during the digital curriculum; almost half of the students (49%) returned to the time having spent learning mathematics before the pandemic. 39% of respondents answered that during the academic year 2021/2022, they spent more time (on average) preparing for math lessons than before the emergency.

The question of commitment is of fundamental importance for students' successful performance (Reschly, 2020). Although the students' motivation often changes from lesson to lesson and from topic to topic, the teaching colleagues could observe spectacular changes in some students' attitude because of the alternation of the different curricula (Figure 13).

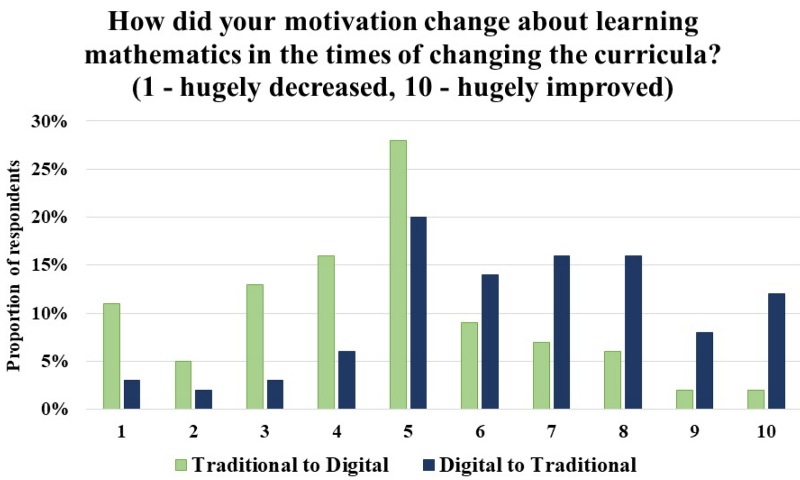

Figure 13. The change of the motivation because of the alternation of the different curricula

In the case of the transition from traditional to digital curriculum, 73% of the students' motivation rather worsened, while upon returning, 66% of the respondents felt improvement regarding their motivation.

According to the students, the return to traditional education was made difficult by the fact that noticeably large backlogs had developed, both at personal and group levels. Under the digital curriculum, it was easier to "hide" from the class presence and work: the students could silence themselves and deal with something else, and based on the answers, this eventually led to incomplete knowledge and a weakened ability to concentrate. For these reasons, it was difficult for many to study at school, because they lost the comfort of home, they had to adapt to the constraints of school, and the teachers expected more activity and discipline during lessons, which was difficult for the students in the early days. The return was made even more difficult by the fact that sitting in front of smart devices (admittedly), the students were more able to use other aids, too, which was not necessarily allowed in school lessons. Several respondents pointed out that they had got used to not waking up early due to the possibly changed schedule of home education, so the bedtime and wake-up time had also been shifted, and all of this resulted in greater fatigue when returning to school with the expectation of increased concentration. The fact that travelling to and from school is a time- and energy-consuming process for many required a similar temporal replanning.

However, the students highlighted that many factors had greatly made it easy to return to school. The greatest motivation was the personal presence and the regaining of social relations, which made the atmosphere of the lessons more friendly. Many people reported that they understood the material more easily during face-to-face teaching. This was due to the helpful, empathetic, and enthusiastic attitude of the teachers, and as well as the smoother flow of teacher-student and student-student interactions. You can also read about the importance of school relationships in Irene García-Moya's (2020) book titled *The Importance of Connectedness in Student-Teacher Relationships*. Various studies suggest that teacher-student relationships are closely linked to learning and well-being in school. The results of the study by Joshi et al. (2022) also showed that learner engagement in online learning in Nepal was found to be high on the social dimension, which plays a major role in determining cognitive engagement. For many students, the constraints mentioned earlier as negative (frames of the lessons, form, expectation of the attention) had an encouraging and motivating effect on the active presence in the lessons of mathematics.

Summary

The return to the on-site educational form brought to the surface both the negative and positive effects and consequences of the digital curriculum.

- The students had to switch several times between systems and adapt to the given conditions. However, for this, they needed discipline, perseverance, and adequate self-knowledge in which there were large differences among each student. Because of all this, they were forced to learn how to study, and how to allocate their time better, so they had the opportunity to create individual learning paths. According to Hodgen et al. (2020), those students who developed as independent learners were disproportionately highly educated and therefore able to self-regulate their learning. On the other hand, the majority of secondary school students are not yet responsible enough, even though this is considered as a key factor in the online learning environment. The quantitative results of the study showed that students' initial enthusiasm and engagement gradually decreased by the end of the trimester (Moliner et al., 2021).

- Distance education also brought pedagogical renewal to the lives of many groups. Materials uploaded during digital education are still available and can be reviewed by students. Many teachers continue to upload learning support materials and blackboard images to the digital classrooms active even during the on-site curriculum.
- Both teachers and students were able to get to know new mathematics-related applications and programs, so modern technology can now have more space regarding the teaching and learning of mathematics. Systems supporting visualization and self-checking have become known and available to many.
- Based on the reports of the students, because of the experienced period, they can appreciate more the traditional classroom education and the personal presence of teachers. In their opinion, their teachers have also improved a lot in the past period. They have become more experimental, braver, helpful, empathetic, patient, creative, and flexible.
- During the digital curriculum, students could more easily use non-permitted tools, it was easier for them to cheat the given system. This strongly influenced the depth of the understanding of the course material at that time.
- In the absence of confident mathematical knowledge, repeating the parts of the curriculum taught during the pandemic, assessing and correcting deficiencies have become a problem to be solved. Generally, research shows that learning gaps are difficult to compensate and persist over time. The deficits that appeared at the beginning of the pandemic have not resolved since then, but they have not increased significantly (Betthäuser et al., 2023).

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