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Home Learning Experiences Through the Covid-19 Pandemic

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Abstract

The COVID-19 pandemic has drastically affected the education process almost all over the world. Some countries closed their schools, Slovakia was among them (schools in Slovakia were closed intermittently for almost two years). Teachers faced the challenge of developing alternative educational practices through digital technologies. Students also faced personal, technological, and social challenges. Distance education, as a replacement of imparting and receiving knowledge, was in many aspects also very demanding for parents. It was necessary to overcome several technical problems (availability of appropriate and reliable Internet connection, provision of appropriate computer equipment and sufficient personal educational space for each member of family). An important role was also played by the student's ability to mobilize his own motivation for asynchronous and autonomous learning. The discussion with the professional public and the review of the relevant literature indicated that the teaching of mathematics is more sensitive to the interruption of attendance education. As the students themselves expressed: for the understanding of mathematical concepts, the personal presence of the teacher necessary and fundamentally affects the student's ability to obtain new knowledge and understand it. The testing of knowledge of students in Slovakia in 2022 at all levels of schools (after almost two years of distance learning) indicates that in the field of mathematics education there has been the biggest drop in knowledge compared to other subjects.

Our study focused on the analysis and uncovering of negative but also positive factors operating in the online teaching of mathematics, which significantly affect the results and level of knowledge of students at the university. Mapping and identification of problematic moments in this process helped us reveal the results of a survey (study) conducted among students of the 1st year of bachelor's studies at the University of Žilina.

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1. Introduction

The disease of COVID-19 and the related pandemic and the resulting closing of schools and school facilities fundamentally changed the way of education in Slovakia. In 2020 and 2021, high schools and universities were closed the longest. Elementary school students (students at the age of 6-10 years) studied online for the shortest time. Universities switched to the distance education regime at the beginning of March 2020. In this year, all teaching processes (lectures, exercises, testing and examination of students) took place in a distance form. Attendance teaching was resumed only in September 2021 for eight weeks, which was followed by the closing of universities again until March 2022.

In March 2020, pedagogical employees found themselves in a completely unique situation, practically overnight. They lacked experience, but also the appropriate technical support for providing quality online teaching. The competences of teachers with online teaching were minimal during this period. E-education was limited to the use of the Moodle system until 2020; through which we sent study materials to students, or sometimes conducted consultations and testing students.

Step by step, the schools adapted to the new conditions. At the University of Applied Sciences in Žilina, the necessary computing technology (tablets, cameras, microphones) was provided, and contact with students was realised in groups through a cooperative workspace Microsoft 365/Office 365, suitable for interactions at the workplace, teamwork, video conferences and file sharing.

Lectures, exercises and seminars were subsequently taking place in the form of video conferences, while the mathematics teacher explained the topic using a graphic tablet, which allowed him to flexibly share mathematical symbols and the necessary graphic elements. By using suitable mathematical software (for example, GeoGebra, Matlab, Graphmatica, etc.), it was possible to present graphs, equations, pictures necessary for high-quality teaching of mathematics. Of course, it required many hours of extra work from the teacher to prepare appropriate, precise and correct materials.

Full-time teaching at the University of Applied Sciences in Žilina was definitively resumed in March 2022. During this period, we held a group discussion with students to obtain feedback regarding online teaching. We were mainly interested in how students assess distance teaching of mathematics, what positives (or negatives) they observed. We were looking for answers to the following questions:

- how did students feel during online mathematics lessons?
- what were their conditions and what, according to them, was the most difficult about online teaching?
- how did they learn without the support of face-to-face contact with teachers and peers?
- to what extent were they able to learn and understand new topics in mathematics?
- would it be appropriate to implement some elements of distance learning in the teaching of mathematics in a daily form permanently?

To examine and evaluate students' opinions, we used a content-verified survey form (questionnaire), which served as a research tool. The sample set for our study consisted of 502 randomly selected first-year undergraduate students at the University of Žilina.

2. Literature review

The issue of the effectiveness of online mathematics education was addressed by many educators before the outbreak of the COVID-19 pandemic itself. This topic is relevant above all in connection with the lifelong, external, and individual education of students with special needs, whose opportunities attendance (in-person) education are limited. Howlett (2009) defined online learning as “the use of electronic technology and media to deliver, support and enhance learning and teaching and includes communication between students and teachers using online content”.

Berge et al. (2000) in their study recommend the following to teachers when teaching online:

- determine and select appropriate (accessible, adequate) hardware and software requirements for the chosen course,
- be available to students for consultation,
- be creative when interacting with students,

- provide regular feedback to students regarding course performance,
- listen to their concerns and problems,
- be proficient in using the capabilities of the online software used,
- use different teaching styles,
- encourage collaboration between students.

Several studies before the period of the COVID-19 pandemic reflected on important factors that have an impact on the results of students educated online. For example, Wadsworth et al. (2007) state that the results of students in online education were directly dependent on motivation, concentration, the student's ability to process and contextualize the information obtained. Interesting results are also presented by Kim et al. (2014), who confirmed the positive influence of motivation, a higher level of autonomous learning and metacognitive abilities of students for successful online mathematical education. We can therefore assume that the results of students in online teaching are conditioned by their ability to regulate their own learning (higher level of so-called autonomous learning, the ability to gain knowledge independently of the type of source). Kim et al. (2014) extended Güzeller and Akin's (2012) study to examine the impact of anxiety and other forms of academic emotions (anger, shame, boredom, enjoyment, and pride) on online mathematics learning outcomes.

During the COVID-19 pandemic, students and teachers also faced significant physical and psychological problems (Baticulon et al., 2021; Bringula et al., 2021). The continuous closure of schools and almost all institutions during the pandemic worsened the already existing and described phenomenon of the digital divide between students; students could not use public access to computers and the Internet (Baticulon et al., 2021). Thus, some students had difficulty engaging in online learning due to limited access to basic online resources. The students also emphasized that the online exam is not only about the correctness of the answers. They also must master the system to enter their answers correctly, which often adds to the stress level of the exam.

The sudden transition from attendance education to online education in March 2020 in Slovakia presented several challenges for all involved. They had to overcome difficulties:

- technical (related to hardware, software, internet connection)
- personal (related to learning style, stress on physical and mental health),
- institutional (administration of study resources, curricula, pedagogical skills)
- community (existing infrastructure problems).

We can also state that online teaching also has many advantages. However, its implementation requires access to suitable computer equipment, a good ability to use them, a reliable Internet connection, and a private (personal) learning space. In the distance learning process, we consider the student's ability to learn independently and acquire a relevant level of knowledge based on available resources to be decisive. The student must be able to watch the teacher's videos or various online resources with understanding. The independent, purposeful and active work of the student is necessary to achieve the set goals and good study results.

Based on a wide pedagogical discussion and available resources, we agree with several authors (Pynos, 2016; Glass, 2008) that mathematics is more sensitive to school dropouts than other subjects. We can see several reasons. Mathematics is almost always formally taught at school, in an attendance format, by explaining through a second person. To acquire mathematical literacy in the sense of being able to apply mathematics in practice, it is not enough just to learn mathematical concepts, formulas, algorithms. Their understanding in mutual context is essential. Parents are often unable to help their children with home tutoring (especially at higher levels of school). Let's also mention other factors:

- Stress and trauma from mathematics, which is very common even in attendance teaching of mathematics, can become even worse in connection with the pandemic and online teaching. Anxiety from maths is aggravated by the stress that is added to the student during online teaching.
- It can be challenging for teachers to realise attractive and effective teaching practices through remote platforms.
- The teacher is not able to apply online such important competencies as empathy, flexibility, kindness, he lacks feedback, he cannot see "into the student's soul" as in personal contact in the classroom. In the discussion, several teachers state how much they missed "eye contact" with the student when teaching, which can reveal so much about the students' understanding or lack of understanding when explaining a given topic

- A relatively large group of students needs the so-called peer group for understanding new mathematical terms. In this group they are discusing about things that are not clear. The need for a supportive peer group is absent in online teaching, and communication via the Internet when explaining mathematical problems is more complex (specific syntax and language of mathematics) than in other subjects.

3. Materials and methods

The selection group is consisted from the students of the University of Žilina in Žilina, who completed the subjects Mathematics 1 and Mathematics 2 in the form of online teaching. 502 students, randomly selected from three faculties of the University in Zilina were addressedin the survey (Faculty of Civil Engineering, Faculty of Operation and Economics of Transport and Communications, Faculty of Special Engineering).

The participants in both the quantitative and qualitative parts of the study were first-year bachelor's students. The survey was conducted after the students returned to face-to-face classes in March 2022. For the last two years, these online students completed most of their mathematics classes online. First, we held a group discussion with them regarding online teaching. Using the initial data obtained in this way, we created a 17-item questionnaire that collected information about the profiles of online students, their access to technological skills, their study habits and practices during online classes, current living conditions, and opinions on online teaching.

Using a 4-point (or 5-point) Likert scale, we asked respondents: (questions 3, 4) how difficult online teaching was for them; (questions 5,13) whether they had adequate technological security and personal space for online teaching; (questions 15,17) whether study resources and teachers' skills were adequate; (question 11) how they perceive students' assessment during online teaching. We also listed 9 negatives of online education (question 8) and asked respondents to select which they thought were relevant to their experience. In open-ended questions during the experiment, we explored any other barriers that students faced during online learning.

Research instrument

To process the obtained data, we first used a simple classification of quantitative signs. We used descriptive statistics tools to create an overview of the acquired data. We have compiled tables of the frequency distribution of the observed signs. We also used a graphic representation of the frequency distribution of the observed signs for a quick and clear presentation of the survey results.

In the second phase, we used the tools of causal analysis of statistical data. We found out the dependence between the technical, and personal background of the student and the level of acquired knowledge during online classes, and the dependence between the student's attitude towards online teaching and the obtained grade in mathematics at the end of the semester. To verify the dependence of two qualitative features A, and B, we used the χ^2 – test for contingency $k \times m$ tables. We carried out the investigation of the dependence between two qualitative features in two steps. First, we verified whether there is a statistically significant dependence between the observed characteristics. Subsequently, we assessed the intensity of statistical dependence within the given statistical set using the contingency coefficients C and Cramer's coefficient V; while valid

$$C = \sqrt{\frac{\chi^2}{\chi^2 + n}}, V = \frac{\chi^2}{min\{(k-1, m-1)\}.n};$$

χ^2 je Pearson test statistic, and $n = \sum_{i=1}^{k} \sum_{j=1}^{m} n_{ij}$.

Analysis of the quantitative characters

Personal attendance in learning process of the University of Zilina was definitively resumed in March 2022. In this period, we held a group discussion with students to gather their feedback about the time when they studied online. We were particularly interested in how students view the online distance learning of mathematics, what positives or negatives they observed. We were looking at questions like:

- How did students feel during the online learning of mathematics?
- What were the conditions for online study?
- What did they feel was the most difficult thing during online learning?
- How did they cope with learning without personal contact with teachers and peers?

- To what extent were they able to learn and understand new mathematics topics.
- Would they incorporate some aspects of online learning into the daily personal form of learning in school?

We used a content-verified questionnaire as our research tool to gather and evaluate the students' opinions. The group of respondents consisted of 502 randomly selected students of public transport and economy-related fields of the Faculty of Operation and Economics of Transport and Communications at the University of Zilina, where 40 % were male and 60 % female. We asked 17 questions, most of which required just one answer, some allowed more than one. We also considered the type of high school they studied before coming to the University of Zilina, where 41 % finished business school, 27 % vocation school and 32 % grammar school.

The first question concerning learning from home and the overall attitude towards it, as many as 29 % of students replied they studied "occasionally, irregularly". A little less students replied they "were discouraged, were not motivated to learn at all" (21 %), "I did not feel involved, it was difficult" (20 %) followed by more positive answers like "online learning was somewhat interesting" (12 %), "I quite liked it" (11 %) and "I liked it very much, online learning was great" (9 %).

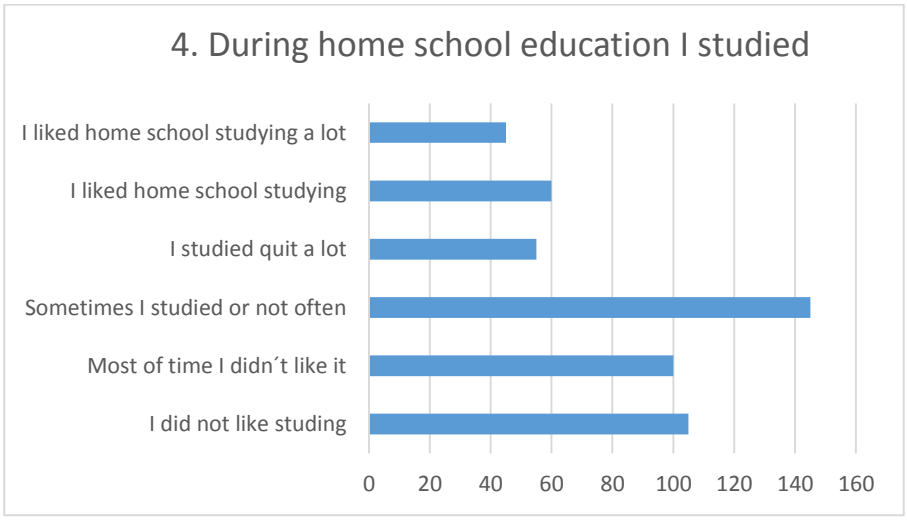

Fig. 1. Answers to the question: "During home school education I studied"

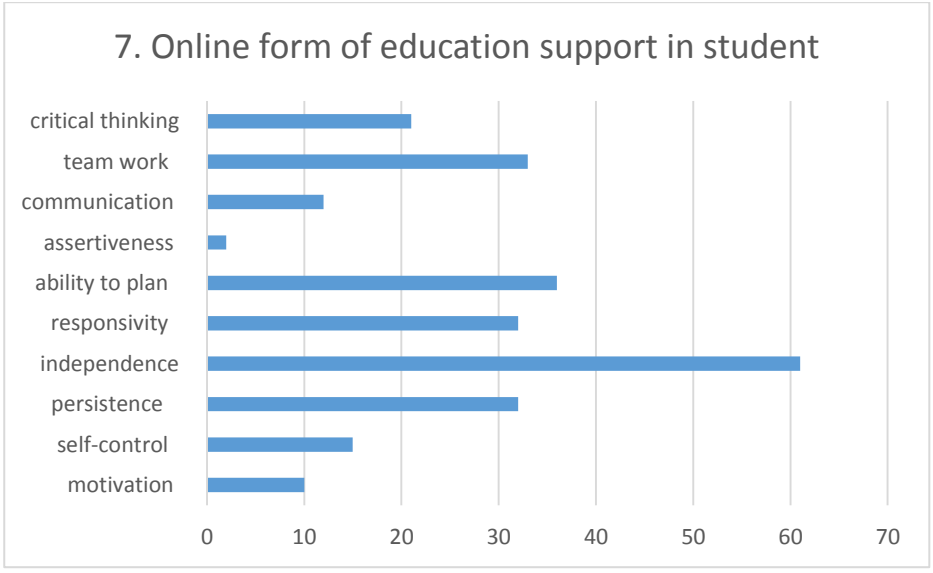

Fig. 2. Answers to the question: "Online form of education support in student"

Many households had to cope with the technical aspects of online learning concerning either the internet connection, hardware, or private space without being disturbed. Majority of students (63 %) responded their conditions for learning were "great" with stable internet connection, own hardware device and private space. Another group of 26 % of students responded their conditions were satisfactory. The last group (11 %) of students had only partially satisfactory or unsatisfactory conditions.

We were also interested in what personal traits or skills do the students feel being cultivated or boosted by the distance form of learning, they could pick more than one answer. Most of them (61 %) responded "self-sufficiency", followed by "ability to plan ahead" (36 %), "teamwork" (33 %), "persistence" (32 %), "responsibility" (32 %), "critical thinking" (21 %), "self-control" (15 %), "communication" (12 %), "motivation" (10 %) and only 2 % of students responded "assertiveness".

As with everything, the online learning process has its positive and negative aspects. We asked students how see the pros and cons and they could again pick more than one answer. The biggest downside (78 %) according to students was the "worsened ability to focus".

The fact that "teacher could not see students and react to their questions when they did not understand" bothered 38 % of the students. Up to 37 % of respondents felt "passivity, not being able to self-motivate and studying very little during this time". Another downside was the "lack of feedback" (33 %), "lagging behind in systematic study on student's part" (29 %), "lack of work in group and studying with peers" (29 %). Other downsides observed by students were "lack of communication with teachers" (27 %), "lack of complex overview about the studied topic" (20 %) and the last with 18 % was "quickly forgetting what we learned".

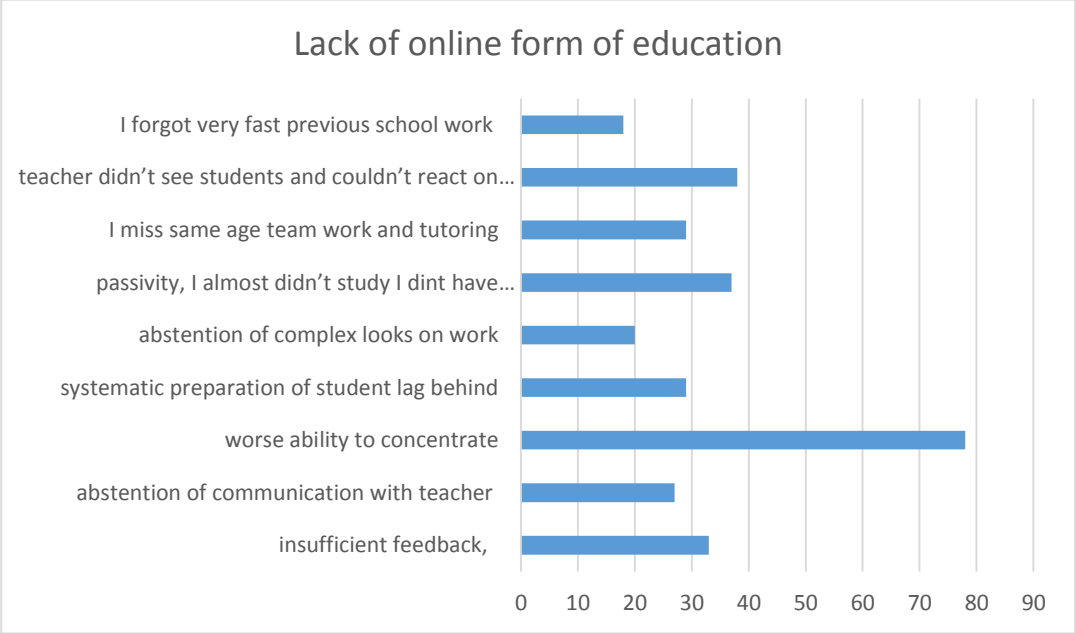

Fig. 3. Answers to the question: "Lack of online of education"

Testing and exams were naturally present even during the online learning period in the form of either online exams or face-to-face testing using computers or other devices with cameras. We wanted to know how students felt about testing and evaluation of their knowledge online. Again, they could pick more than one answer and 58 % of them felt that the trustworthiness of online testing is inferior to in-person testing, 33 % of students resorted to some form of cheating during exams and 24 % of them does not consider this form of testing to accurately reflect their true level of knowledge. Only 14 % of students considered this form of testing to be fair and trustworthy.

Students had to spend a lot of time using the computers or other electronic devices daily. Even so, 32 % of students stated they were dutifully sitting by the table and taking notes during the online lessons. Up to 66 % of them stated that they were taking notes irregularly, which can be attributed to the fact, that many teachers recorded the lessons and shared the materials to be

available anytime the students needed. Only 2 % of students stated that they did not work at all during online lessons.

Analysis of the qualitative characters

In the second stage of our study, we used a database of obtained data and implemented an analysis of qualitative signs. It was possible to analyse the dependence of several pairs of qualitative signs. Based on formulation of a research problem, we have stated the following hypotheses for the verification:

H_1: The level of the student's technological and study background and the achieved level of knowledge in mathematics are statistically significant dependent signs.

H_2: The relationship of the students to online education and the level of achieved knowledge in mathematics are statistically significant dependent signs

H_3: Student´s learning in an active position (working while sitting at a desk with a laptop, taking notes) during online education and the level of acquired knowledge are statistically significantly dependent signs.

We used χ^2 – test for contingency table k x m to verify dependence of each pair of the qualitative characters A and B. The character A was acquiring k categories and the character B was acquiring m categories. We tested the null hypothesis:

H_0: the characters A and B are independent versus H_i: the characters A and B are dependent.

The rejection region is $\chi^2 > \chi^2_\alpha\left((k-1),(m-1)\right)$, where $\chi^2_\alpha\left((k-1),(m-1)\right)$ is the critical value of χ^2 – distribution with $\left((k-1),(m-1)\right)$ degrees of freedom. We set a significance level $\alpha = 0{,}05$. The degree of statistical dependence between the observed qualitative characters A and B is assessed using the contingency coefficient C and the Cramer coefficient V.

Verification of H_1 hypothesis

The data obtained from 502 respondents, who formed an experimental group, were used in the verification process of the hypotheses. For n = 502 elements of a chosen group we observed qualitative signs A and B. Sign A indicates *the level of the student's technological and study background* and sign B indicates *the level of knowledge in mathematics:*

Sign A acquires levels A_1 = *excellent*, A_2 = *sufficient*, A_3 = *unsatisfactory*.

Sign B acquires levels B_1 = excellent, B_2 = *very good*, B_3 = *good*, B_4 = *satisfactory*, B_5 = *sufficient*, B_6 = *failed*.

As a test criterion we applied a statistic χ^2 (*chi – square test)*. To calculate the value of the testing statistic χ^2 we used Microsoft Excel. By inserting the function CHITEST for the input data we got the value χ^2 = 12,681 and the probability value $p = 0{,}24204$ in the output report. Since value p is larger than 0,05 on the level of significance α = 0,05 we do not reject a hypothesis about an independence of observed signs. That means *the level of the student's technological and study background* and *the level of knowledge in mathematics* during the online education *were* independent.

Verification of H_2 hypothesis

For n = 502 elements of a chosen group we observed qualitative signs A and B. Sign A was *the relationship of the students to online education* and *sign B* indicates *the level of knowledge in mathematics:*

Sign A acquires levels A_1 = *I enjoyed it very much*, A_2 = *it was fun*, A_3 = *I enjoyed it sometimes*, A_4 = *mostly not fun*, A_5 = *I didn't enjoy it at all*. Sign B acquires levels B_1 = *excellent*, B_2 = *very good*, B_3 = *good*, B_4 = *satisfactory*, B_5 = *sufficient*, B_6 = *failed*.

The test statistics is χ^2 = 127,53. The critical value with 20 degrees of freedom is χ^2_α (20) = 31,17. The probability value $p = 1{,}126.10^{-7}$ in the output report. The rejection region is χ^2 = 127,53 > 31,179 and thus we reject the null hypothesis about the independence of phenomena A, B. It is evident that the *relationship of the students to online education* of mathematics and level *of knowledge in mathematics* were dependent phenomena.

The value of contingency coefficient is $C = 0{,}4508$ and the value of Cramer coefficient is $V = 0{,}2525$. The value of these coefficient indicates that between the analysed qualitative characters A and B there exists the mild degree of connection.

Verification of H_3 hypothesis

For n = 502 elements of a chosen group we observed qualitative signs A and B. Sign A was style of student´s learning (an active position sitting at a desk with a laptop, taking notes) during online education and sign B indicates *the level of knowledge in mathematics:*

Sign A acquires levels A_1 = *always*, A_2 = *sometimes*, A_3 = *almost not at all*, A_4 = *mostly not fun*, A_5 = *I didn't enjoy it at all*. Sign B acquires levels B_1 = excellent, B_2 = *very good*, B_3 = *good*, B_4 = *satisfactory*, B_5 = *sufficient*, B_6 = *failed*.

The test statistics is $\chi^2 = 34{,}086$.The critical value with 10 degrees of freedom is $\chi^2_\alpha\,(10) = 18{,}3$. The probability value $p = 9{,}36.\,10^{-8}$ in the output report. The rejection region is $\chi^2 = 34{,}086 > 18{,}3$ and thus we reject the null hypothesis about the independence of phenomena *A, B*. It is evident that the *relationship of the students to online education* of mathematics and level *of knowledge in mathematics* were dependent phenomena. The value of contingency coefficient is $C = 0{,}2526$ and the value of Cramer coefficient is $V = 0{,}1846$. The value of these coefficient indicates that between the analysed qualitative characters *A* and *B* there exists the weak degree of connection.

4. Discussion

The responses of the respondents in the questionnaire, as well as private conversations with students, revealed to us the biggest problems during online teaching. Several of our results correspond with already published studies.

The authors of Baticulona et al. (2021) and Fabio et al. (2021) state that students had a big problem with personal learning space, which negatively affected their learning. Lack of privacy, limited study space was one of the most serious barriers to online teaching. The students, who do not have sufficient educational space, they are often interrupted during lessons and are thus in a disadvantaged situation.

Cavannaugh et al. (2009) reports on the problems caused by the lack of relevant study materials during online teaching. We have to definitely agree with him. Our interviews with several teachers confirmed similar problems in Slovakia as well. During the pandemic, teachers had to manage both online teaching (being available to students) and preparation of the materials, which was often very exhausting.

In a recent study Binti Abd Aziz et al. (2020) also explored barriers to online learning. They identified barriers in the area of students' attitudes, technological skills and personal skills. They evaluated the negative attitude of students towards the online form of education as a cardinal barrier. Our study also confirmed a significant dependence between the students' attitude to online education and the results achieved during the exam. It has been confirmed that the relationship to online teaching has a strong influence on the level motivation of the students and, consequently, on the level of acquired knowledge. This result was also confirmed by Pena-Bandalaria (2009) in her research in the Philippines. They also state that students who have a positive attitude towards self-study usually have no problem with online learning and logically achieve better results on the exam.

Fabito et al (2021) found that the lack of contact in clarifying topics through open discussion with the professor, was a major problem in online teaching. They state, and we have to completely agree with them, that neither teachers nor students were sufficiently prepared for such a drastic transition to the online space.

Interesting insights are provided by Benson (2001) and Fotiadou et al. (2017), who emphasize a strong positive relationship between excellent technical skills, online literacy and a well-developed autonomous learning ability and success in exams during online teaching.

Our results confirm that more than three quarters of students could not concentrate well during online classes, they lacked feedback and the possibility of direct communication with the teacher. It was difficult for them to understand the curriculum on their own. The majority of students said that the assessment during the online exam is not trustworthy (58 %) and more than 30% of students admitted to "cheating" during the exam.

Many students felt too frustrated and isolated during online teaching, and had low self-esteem. They did not believe that they could master the mathematics curriculum on their own.

The hypothesis about the dependence of the level of the learning space and the level of acquired knowledge could not be confirmed in our research. As many as 66 % of students rated their personal working conditions as excellent in the test, although in private conversations the majority emphasized a poor ability to concentrate, despite appropriate technical equipment. These results indicate that the problem in online teaching may be the lack of self-motivation, which implies a weak interest of the student in the topics covered and thus also a weak concentration during teaching.

Taking notes and working with printed materials during online teaching has also been shown to have little effect on math learning outcomes.

The results of our experiment are only limited in nature given the small sample size. It would be necessary to test the selected hypotheses on a larger sample of respondents.

In conclusion, we have some recommendations for the teachers themselves in the online teaching process: At the beginning of the lesson, students should be encouraged to take an "active attitude" during the lesson, work at the desk, take notes and try to participate in the lesson in the form of questions. Teachers must assure online students that online consultation is available if needed. Timely feedback on online students' work is strongly encouraged to maintain a positive view of their abilities. One-to-one feedback can be provided to inform online learners that they are performing well (or not well) compared to his/her peers.

5. Conclusion

Our study also proved that the teacher's personality, his computer literacy and the ability to engage students even "at a distance" have a decisive influence in online teaching. Teachers must be creative in delivering course content. For example, PowerPoint slides with a voice recording or a video from the previous lesson can be made available to students. These materials can be accessed at any time and the students with slow internet connections can watch the course at any time. The teachers can conduct synchronous learning sessions to answer the questions or clarifications. The teacher's unwavering dedication and understanding is suggested to help online students complete the course. In the study, we also revealed problems during online teaching that the teachers themselves cannot solve. The family members of the students need to understand that online students need space for physical learning and minimal distractions. Cooperation and understanding from family members is essential to create an environment conducive to online learning.

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