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Original Paper

Comparison of full-time and distance education of Mathematics at the Slovak University of Agriculture in Nitra

Tomáš Pechočiak*

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Institute of Statistics, Operation Research and Mathematics, Slovak Republic

ABSTRACT

The dangerous coronavirus SARS-CoV-2, which causes COVID-19, has been spreading around the world from the Chinese city of Wuhan for more than 15 months. More than 3.4 million people in the world have already contracted this disease, more than 12,290 in our country. As the virus spreads mainly through physical contact, to protect the health and lives of students and teachers, it was necessary to close universities and transfer teaching to the online space. The Slovak University of Agriculture in Nitra has also switched to the distance form of study since March last year. In this paper, we compare the methods and forms of teaching mathematics in full-time study before and after the appearance of COVID. We compared teaching in the school year 2019/2020, when we taught in-person, and 2020/2021, when the teaching was carried out in a distance form. In both cases, we took into account the study at the Faculty of Economics and Management in the subject Mathematics IA, which is taught in the winter semester of the given school year. In this paper, we evaluated the partial score results those students achieved during the semester and their results of final exams. Both years differed in the number of partial semester works. We used the methods of mathematical descriptive statistics for this evaluation. We created databases in Excel, from which we calculated the average point evaluation of individual components and the total number of points. We also calculated the correlation coefficients between the individual parts of this course, for which students could get points. In this way we recorded the data obtained in tables and graphs. We tested hypothesis that students of full-time study would achieve better results than distance-learning students. After comparing the obtained results, we found that this hypothesis was not approved.

KEYWORDS: full-time education, distance mathematics education, coronavirus pandemic, mathematical-statistical analysis, correlation coefficient

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* Corresponding author: PaedDr. Tomáš Pechočiak, PhD., Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Institute of Statistics, Operation Research and Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic. E-mail: tomas.pechociak@uniag.sk

INTRODUCTION

Since the coronavirus was discovered in Wuhan, China, in December 2019, a COVID-19 pandemic has spread around the world. As of 24 May 2021, more than 167 million positive cases and more than 3.48 million deaths from COVID-19 had been confirmed in more than 190 countries and regions of the world, and these numbers are expected to be several times higher [3]. The USA, India, Brazil, France, and Turkey are most affected.

The first cases appeared in Slovakia at the beginning of March 2020, based on which the government took tough measures. As of 24 May 2021, 388,854 people had tested positive and 12,296 had died because of the disease [4].

This pandemic has affected all areas of life, not only healthcare, but also industry, catering, tourism, and the like. Of course, she did not bypass education at all levels, not excluding higher education. The virus is most often spread by close physical contact, so it was necessary to transfer full-time teaching to the online space. From the beginning of March 2020, students of the Slovak University of Agriculture switched to distance learning. This applies to lectures, exercises, but also verification of knowledge, either continuously, but also by the final exam.

As stated in [11]: "Mathematics is more than science, it is the language of all sciences." According to Álvarez et al. [1] Mathematics plays a key role in every engineer's curriculum because it provides a theoretical basis for various theories of natural sciences. Pechočiak and Kecskés [9] say that the use of mathematical and statistical methods not only allows the detection of the occurrence of certain phenomena in the new global environment, but indirectly requires special attention. Országhová and Horváthová also dealt with statistical analysis of mathematical and linguistic competencies [7]. Also Cígler [2] deals in details with mathematical abilities and mathematical skills, stating the main differences, ways in which they arise and could be measured. Results of didactic research in different countries have confirmed that students' interest in science subjects is decreasing and students come across difficulties in STEM subjects (i.e., science, technology, engineering, and mathematics) [10].

In the distance form of study, teachers as well as students had to reorient themselves to work with computer technology. Teachers became programmers, creators of online teaching materials. In many cases, they used their own computing resources for this work, working at home, where they met other members of the household, and had to harmonize the requirements of all.

MATERIAL AND METHODS

In our paper, we decided to compare the teaching of mathematics before and after Covide. We compared the teaching of the subject Mathematics IA, which is taught at the Faculty of Economics and Management in the winter semester. We researched teaching in the school years 2019/2020 and 2020/2021. In the first of the mentioned years, the teaching took place classically, in person, in the second we switched to distance education online. Matušek and Hornyák Gregáňová [6] also dealt with the comparison of exam results in Mathematics.

The scoring system according to the ECTS scale has been operating at our school for several years. Therefore, both continuous evaluations and exams are awarded points.

The winter semester of the school year 2019/2020 took place in person, so the students personally participated in lectures and exercises led by teachers from the Department of Mathematics FEM SUA in Nitra. During this semester, students were able to earn 35 points for the preliminary test they wrote in about the sixth week. They wrote the test at school in practice and had 60 minutes to complete it. We present an example of such a preliminary test:

1. If the function $f: y = x^2 - 3x + 4$ is called, which is its graph, sketch it.
2. Calculate the definition area $D(g)$ of the function $g: y = 2 - 5\ln(3 - 2x)$ and find the inverse function g^{-1} to it.
3. Find the asymptote without the direction of the function graph and sketch it, when $h: y = \frac{2-x}{3+x}$.
4. Write a definition of the bounded function from above and give an example.

In about the eighth month, after taking over the issue, students were given a homework seminar, for which they could get another 15 points. It concerned the examination of the course of the function, i.e., finding out the properties of the function and then drawing its graph. The function was in the form of a fraction, for example $f: y = \frac{2-x}{3x^2}$. They had a week to work it out.

During the semester, students could get an additional 5 bonus points for completing short homework or activity in exercises. Thus, during the semester, students were able to gain a total of 55 points. They needed at least 30 points to be awarded credit. 92 students got to this stage of the semester. Students with credit could take the exam, which lasted 90 minutes and could get 50 points for it. Here is an example of such an exam written work:

1. If the function is called $f: y = \log_6(x - 4)$, which is its graph, sketch it.
2. Find the monotonicity intervals of the function $g: y = 2x^3 + 6x^2 - 18x + 7$.
3. Find the inflection points of the function $h: y = 2x^4 - 4x^3 - 24x^2 + 10x + 7$.
4. Find the local extrema of the function $k: z = x^2 + 6y^3 + 18y^2 - 6xy + 18y - 18x$.
5. Calculate the second partial derivatives of the function $z = \cos(3x - 4y)$.
6. Write a definition of a descending function and give an example.

During the winter semester in the school year 2020/2021, which was already taking place online, students wrote 6 individual assignments, in which they found 3 tasks. All teachers of our department participated in the creation of these assignments. We evaluated each correctly calculated assignment with 9 points. In the first assignment, students had to display graphs of linear and quadratic functions and write their properties and write the definition of some given property. In the second assignment they had a given exponential or logarithmic function (for example $f: y = 4^{x+1} - 32$), they had to express its inverse function and display graphs of both functions. In the third assignment, they had to find out the equations of asymptotes without a directive and with the directive of the graph of the function *f* (for example $f: y = \frac{3x^2}{2x-6}$) and write one of the theorems or definitions concerning the limits of functions. In the fourth assignment, students counted 2 examples of derivatives of functions and had to write a

definition or sentence concerning the derivation of a function of one variable. The sixth assignments included examples from economic applications of derivatives, the calculation of the first and second partial derivatives of the function of two real variables, and a theoretical question in this area. Here is an example of such an assignment:

1. The function of total costs has the expression $TC(x) = x^4 - 8x^2 + 6000$, where x is the level of production in thousands. Find out for which level of production the total costs are minimal and state the size of the costs.
2. Calculate the partial derivatives of the 1st and 2nd order of the function $f : z = \frac{x^2}{4y}$.
3. Define the partial derivative of the function of two real variables according to the variable *x*.

Students from these six assignments could get 54 points. Of this total number of points, in order for a student to obtain a credit and be able to register for the exam, he also needed at least 30 points as in the previous year. Together we evaluated the results of 114 students. After obtaining the credit, students wrote an exam written work for 50 points, which contained 5 examples for calculation and 1 theoretical question from the curriculum of the whole semester. We also give an example of such an exam written work:

1. Find the equation of the asymptote with the direction of the graph of the function $f : y = \frac{3-2x}{3x-2}$ and sketch it.
2. Find the local extrema of the function $g : y = 4x^3 - 12x^2 - 36x - 10$.
3. Find the convexity and concavity intervals of the function $h : y = x^4 + 2x^3 - 12x^2 + 20x + 17$.
4. Find the local extrema of the function $k : z = 4x - y - x^2 - y^2 - xy + 5$.
5. Calculate the second partial derivatives of the function $z = 5x^2y^3 - 4xy^2 + 3xy + 2\cos y - 8$
6. Write the definition of the descending function and give its example (by the equation).

The points obtained during the semester and the points from the exam were counted and we evaluated the overall success of the student using the ECTS scale. At least 64 points were needed to successfully complete the study of this subject.

The results we obtained during these two years were evaluated in the next part of the work. In our work we were also inspired by the textbook of colleagues from CPU Nitra [5]. We used the methods of mathematical descriptive statistics, while we created databases in Excel by arranging the results of individual parts of this subject for each student under each other. From the data arranged in this way, we calculated the average point evaluation of individual components and the total number of points. We also calculated the correlation coefficients between the individual parts of this course, for which students could get points, i.e., whether it applies if students master one part, they manage others, that is, whether there is any dependence between them. A weak dependence is when the correlation coefficient is from an interval $\left\langle -\frac{1}{3}, \frac{1}{3} \right\rangle$, a medium dependence for values from intervals $\left\langle -\frac{2}{3}, -\frac{1}{3} \right) \cup \left(\frac{1}{3}, \frac{2}{3} \right\rangle$ and a

strong dependence for values from intervals $\left\langle -1,-\frac{2}{3}\right)\cup\left(\frac{2}{3},1\right\rangle$. Similarly, we addressed such an issue in the paper [8]. We also set a hypothesis: Students who attend full-time will achieve better results compared to students who have studied remotely.

RESULTS AND DISCUSSION

As mentioned above, students in the school year 2019/2020 could get 35 points for preliminary test, 15 points for home seminar work, 5 bonus points and 50 points for exam written work. The average number of points obtained in this way, even with a percentage expression for all 92 students, is given in Table 1 and we can also see them in Figure 1.

Table 1 Points obtained during the winter semester in the school year 2019/2020

	PT	**HSW**	**BP**	**∑ P+H+B**	**EWW**	**TP**
AVERAGE NUMBER OF POINTS	23.13	13.67	3.4	40.20	35.36	75.56
%	66.09	91.11	68.00	73.09	64.28	68.69

Source: own

Explanations of the abbreviations in the Table 1:
PT – the points obtained of preliminary test, HSW – the points obtained of home seminar work, BP – bonus points
∑ P+H+B – the sum of points obtained during the semester
EWW – the points obtained of the exam written work, TP – total points

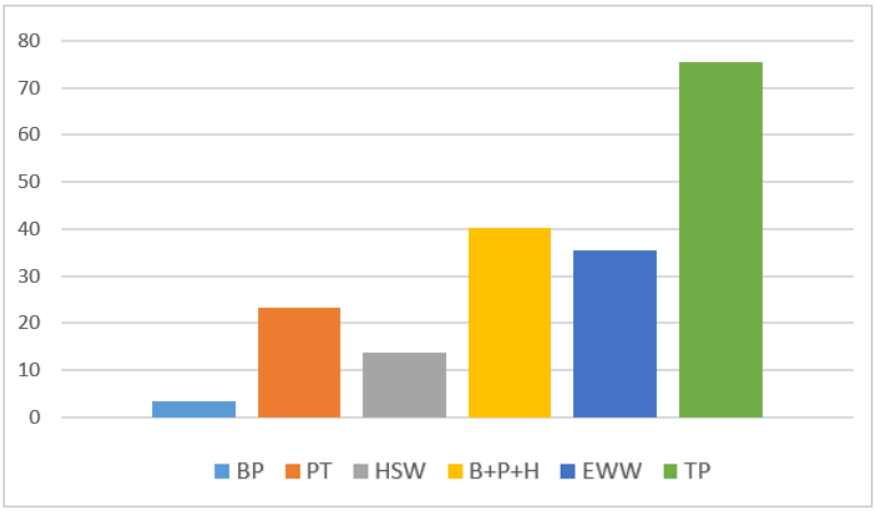

Figure 1 Points earned during the winter semester 2019/2020
Source: Calculation of author

They received the most points for the home seminar work, on average 13.67 points, which represents 91.11% of the total number of points. For the semester, they gained an average of 40.2 points, which is 73.09% of the total number of 55 points. They wrote the exam written work on average at 64.28%, which is 35.36 points out of 50 points. The sum of all points obtained averaged 75.56 points out of 105.

We also calculated the correlation relations between the points obtained for the preliminary test, the sum of the points obtained for the credit (preliminary test + seminar work + bonus), the points for the exam written work and the total sum of points (Table 2).

Table 2 Correlation coefficients between individual items for the year 2019/2020

	PT	**∑ P+H+B**	**EWW**	**TP**
PT		0.961	0.257	0.706
∑ P+H+B	0.961		0.304	0.759
EWW	0.257	0.304		0.851
TP	0.706	0.759	0.851	

Source: Calculation of author

As can be seen from this table, there was a weak relationship between the preliminary test and exam written work and the sum of points for the semester and the exam written work. We assume that the student underestimated the exam when he obtained a relatively large number of points per semester, or vice versa, when he gained few points during the semester, he was better able to prepare for the exam. There was a strong dependence between the other categories.

In the school year 2020/2021, students were able to obtain 54 points for 6 individual assignments and 50 points for the written exam. These obtained average numbers of points, even with a percentage expression for all students, are shown in Table 3 and Figure 2.

Table 3 Points obtained during the winter semester in the school year 2020/2021

	$\sum A_i$	**EWW**	**TP**
AVERAGE NUMBER OF POINTS	43.11	38.03	81.14
%	79.84	76.05	78.02

Source: Calculation of author

Explanations of the abbreviations in the Table 3:
$\sum A_i$ – the sum of points obtained during the semester
EWW – the points obtained of the exam written work
TP – total points

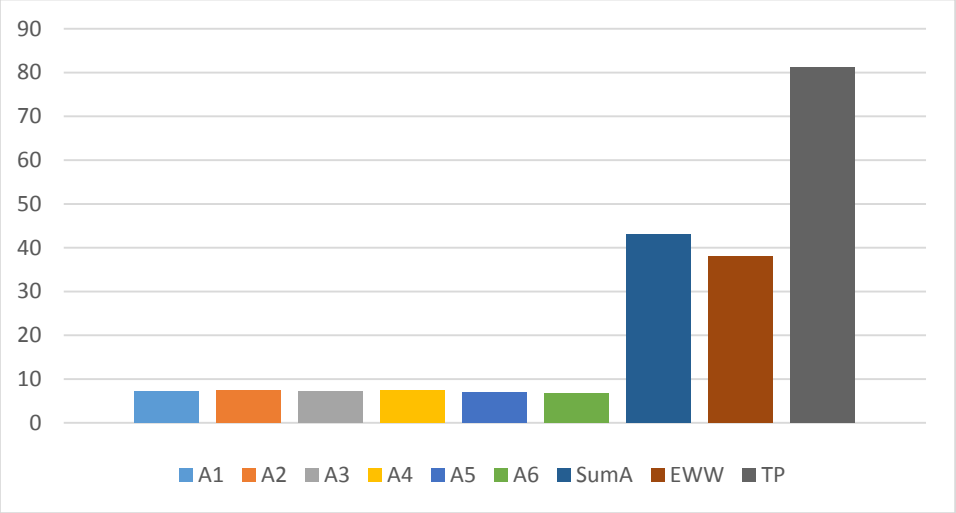

Figure 2 Points earned during the winter semester 2020/2021
Source: Calculation of author

The average number of points for individual assignments was from 6.85 to 7.46 out of 9, which is in percentages from 76.07% to 82.9%. The average total of points was 43.11, which represents 79.84% of 54 points. They wrote the exam written work on average at 76.05 percent, or 38.03 points out of 50. The average sum of points for the semester and the exam was 81.14 points, which is 78.02% out of 104 points.

Also in this case, we calculated the correlation coefficients between the individual points obtained during the semester. We entered them in Table 4.

Table 4 Correlation coefficients between individual items for the year 2020/2021

	$\sum A_i$	**EWW**	**TP**
$\sum A_i$		-0.119	0.204
EWW	-0.119		0.315
TP	0.204	0.315	

Source: own

As we can see from Table 4, all dependencies are weak, so they are out of range $\left\langle -\frac{1}{3}, \frac{1}{3} \right\rangle$.

This means that if a student had enough points from the assignment, he did not have to get a large number of points from the exam, or if he got a larger number of points from the exam, he did not have to get a large number of points from the assignment. It was similar in the previous school year, when there were cases where students had relatively many points during the semester and few points from the exam work, or vice versa.

In the introduction, we set the hypothesis: Students who attend full-time will achieve better results compared to students who study in distance form. We assumed that during contact teaching the student would be better prepared for the written work, as the students counted the

examples on the board in the exercises, we commented on the whole procedure and students could react immediately if they had a problem solving. However, this assumption was not met. Students studying in distance form achieved on average 9.33% better results than full-time students. We explain this by saying that students in online teaching had a lot of time to do partial written work better (they earned 6.75% more points on average) and similarly in the exam, although they had almost the same time to do it, these students could use aids, or even cheat (they gained up to 11.77% more points here than students who took the full-time exam).

CONCLUSIONS

The coronavirus pandemic, which has been spreading around the world for almost a year and a half, has also affected higher education. From face-to-face teaching, from face-to-face teaching, we had to switch to distance learning, which we did mainly online. Because we did not want to reduce the level of mathematics education at our university, we, teachers, and students had to switch to education through online means. Many of us used our own computer technology to do this. In our work, we showed how we had to change the way of teaching and especially the control of acquired knowledge by students. We compared the results of mathematics studies obtained in person and online. We found that students studying online achieved better results than full-time students.

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