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Evaluation of Distance Education in Mathematics at the Slovak University of Agriculture in Nitra

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Abstract: *The COVID-19 pandemic has caused disruption of education systems, from elementary and secondary schools to colleges and universities. This situation also affects the education conditions at the Slovak University of Agriculture in Nitra. Teaching process has been transferred from full-time to distance learning in virtual space. The main goal of the paper was to analyze how students of economics study programs mastered mathematical topics in conditions of distance learning. Correlation coefficient and Mann-Whitney U test were used to identify relations and significance of differences between points obtained in preliminary written assignments as well as the overall study results. In both research groups, taught in Slovak and English, results showed strong correlations between the number of points in exam test and the total number of points. In the English taught group the second strong correlation was confirmed between the total number of points and the points sum for all preliminary assignments.*

1. INTRODUCTION

The COVID-19 pandemic, caused by the transmission of an acute respiratory syndrome called SARS-CoV-2, has been raging worldwide for more than a year. The virus was first discovered in December 2019 in the Chinese city of Wuhan. By May 17, 2021, more than 163 million positive cases and more than 3.39 million deaths from COVID-19 had been confirmed in more than 190 countries or regions throughout the world. USA, India, Brazil, France and Turkey (*COVID-19 Coronavirus Pandemic*) are the most pandemic affected countries. In Slovakia, the first case of this disease appeared on March 6, 2020. By May 17, 2021, 387,659 people had been tested positive and 12,238 had died as a result of the disease *(Coronavirus in Slovakia in numbers*).

The pandemic has affected all areas of life, be it industry, healthcare, tourism, catering, etc. Of course, it has also influenced education at all levels, including higher education (Hudáková et al., 2020). This situation impacted millions of pupils, students and teachers all around the world. As a consequence, it was inevitable to close down schools, colleges and universities in order to protect the world's student population. This situation has also affected the education conditions at the Slovak University of Agriculture in Nitra (Slovak Republic). Since the beginning of March 2020, students have been participating in distance learning. New teaching and education methods have been introduced in teaching methodology in lectures, seminars and knowledge evaluation, either continuously during the semester or in the final exam.

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Current requirements on the graduates combine quality training and mastering of digital technologies for communication and data processing (Országhová, 2018; Országhová, Hornyák Gregáňová, 2020). This trend was accentuated during the pandemic, when profound mastery of information technology tools was necessary to ensure higher education *(Strategy of digital transformation of Slovakia 2030, 2019)*. Distance education runs without the presence of students in the traditional form of teaching and its essence lies in independent study and it is also promising for further education of adults (Tomková, 2018).

In the era of information technology, personal development of teachers and development of training institutions are in mutual relation. The continuous development of society and technology introduce higher requirements on teachers, therefore institutions and teachers must co-operate to bring new methods into education and update the content of study (Batsenko et al., 2020). Students who study with the support of information technology tools must know principles of individual learning and self-discipline in order to apply benefits of e-learning in an appropriate way (Stoyanets et al., 2020).

Economic study programs include mathematical subjects which utilize applied mathematical methods and express relations in quantitative forms (Rozhkova et al., 2017; Álvarez, et al. 2018). Universities prepare graduates for the labor market where they will use mathematical knowledge to solve various practical problems (Farkašová, 2013). The use of mathematical and statistical methods allows only a detection of the occurrence of certain phenomena in the new global environment (Pechočiak, Kecskés, 2016). The analysis of study results in mathematics is an important tool for teachers who use appropriate methods and forms of education to develop and improve students' mathematical knowledge (Matušek, Gregáňová, 2019). An important role of schools is to prepare the young generation for professional life where they are able to use information and communication technologies which are linked to new competencies.

2. METHODOLOGY

In the paper, the authors analyze how students of the Faculty of Economics and Management of the Slovak University of Agriculture in Nitra managed the study of mathematics in a distance form. The authors evaluated the results of preliminary assignments as well as the overall results of the study by means of selected mathematical and statistical methods, calculation of correlation coefficient and Mann-Whitney U test in the Microsoft Excel 2013 program. The material for students' knowledge evaluation in the subject of Mathematics IA in the winter semester 2020 contained 6 assignments, all consisting of 3 tasks. Each correctly solved assignment was awarded 9 points. All teachers of the Department of Mathematics participated in the creation of assignments; here we present the thematic focus of assignments:
Assignment Z1: Graph of linear function, graph of quadratic function and their features.
Assignment Z2: Graph of exponential and logarithmic functions and their features.
Assignment Z3: Limit of a function and asymptotes of a function graph.
Assignment Z4: Compute the derivative of a given function.
Assignment Z5: Features of a function with the usage of derivative.
Assignment Z6: Application of derivative in economics problems.
Partial derivatives of a function with two variables.

Out of the total of 54 points in assignments, at least 30 points were necessary to get a credit. Students then took an exam test for 50 points, which contained 5 problems and 1 theoretical question from the semester curriculum. Here is a sample of an exam test:

1. Determine the equation of the slanted asymptote of $f: y = \frac{3-2x}{3x-2}$. Sketch the asymptote in the coordinate system.
2. Determine the local extremes of $g: y = 4x^3 - 12x^2 - 36x - 10$.
3. Determine the intervals of convexity and concavity of $h: y = x^4 + 2x^3 - 12x^2 + 20x + 17$.
4. Determine the local extremes of $k: z = 4x - y - x^2 - y^2 - xy + 5$.
5. Compute the second partial derivatives of $z = 5x^2y^3 - 4xy^2 + 3xy + 2\,cos\,y - 8$.
6. Write the definition of a decreasing function and illustrate with an example (equation).

Points obtained in the semester and the exam were added and the authors evaluated the overall achievement of students according to the ECTS scale. For a successful completion of this subject it was necessary to obtain at least 64 points according to the following scale: 93 - 100%: excellent - A (1), 86 - 92%: very good - B (1,5), 79 - 85%: good - C (2), 72 - 78%: satisfactory - D (2,5), 64 - 71%: sufficient - E (3), 0 - 63%: fail - FX (4).

The obtained results were evaluated by selected methods of mathematical statistics. In the Excel program the authors created databases by organizing the results of evaluated tasks from each student. Altogether, the results of 114 freshman students taught in Slovak and 33 freshman students taught in English were evaluated. From these data the authors calculated the average score in individual tasks, as well as the average of the total number of points, further they calculated the correlation coefficients between the evaluated parts in order to find out a dependence between them. A weak dependence is when the correlation coefficient falls into the interval <-1/3,1/3>, a mean dependence is for the values from intervals <-2/3, -1/3) ∪ (1/3, 2/3> and a strong dependence is for the values from intervals <-1, -2/3) ∪ (2/3, 1>.

Another goal was the analysis of study results between groups of students taught in Slovak and English language. The authors investigated whether teaching mathematics in English had an impact on students' results in assignments, as well as on the results in the overall evaluation. Using the Mann-Whitney U test, they verified the null hypothesis that two independent random selections (X_1, X_2, ..., X_m) and (Y_1, Y_2, ..., Y_n) are from the same basic set, i.e. they have the same distribution function (Markechová et al., 2011). The first selection consisted of data from point evaluation of students in the group taught in Slovak; the second selection consisted of data from point evaluation of students in the group taught in English. The results of the analysis are presented in the next part of the paper.

3. RESULTS

During the semester, students could get 54 points for 6 sets of assignments (9 for each) and 50 points for the exam written test. In total, they could get 104 points. The average number of points together with percentages in a group of students taught in Slovak are given in Table 1 and a group of students taught in English in Table 2.

As we can read from the tables, students taught in English achieved a lower average number of points in assignments Z2, Z3, Z4 and Z5 and higher in assignments Z1 and Z6. The average number of points in the exam was approximately the same, the total number of points upon completion of the study was circa about 1.6 points worse in the English group. In Slovak groups the average overall evaluation was at the level of good - C (2), in English groups at the level of satisfactory - D (2,5).

Table 1. Points in a group of students taught in Slovak

	Z1	Z2	Z3	Z4	Z5	Z6	∑Z	Exam	∑Z Z+Exam
Average	7.24	7.46	7.14	7.44	7.00	6.85	43.11	38.03	81.14
%	80.41	82.90	79.29	82.66	77.73	76.07	79.84	76.05	78.02

Source: Authors

Table 2. Points in a group of students taught in English

	Z1	Z2	Z3	Z4	Z5	Z6	∑Z	Exam	∑Z Z+Exam
Average	7.27	6.03	6.55	7.30	6.15	8.00	41.30	38.24	79.55
%	80.81	67.00	72.73	81.14	68.35	88.89	76.49	76.48	76.49

Source: Authors

Table 3. Correlation coefficients between assignments in the group taught in Slovak

	Z1	Z2	Z3	Z4	Z5	Z6	Sum Z	Exam	Total
Z1		0.213	0.200	0.191	0.124	0.140	0.536	-0.119	0.204
Z2	0.213		0.160	0.131	0.225	0.029	0.510	0.041	0.315
Z3	0.200	0.16		0.097	0.342	0.151	0.592	0.059	0.375
Z4	0.191	0.131	0.097		0.296	0.207	0.525	0.080	0.355
Z5	0.124	0.225	0.342	0.296		0.248	0.679	0.021	0.394
Z6	0.140	0.029	0.151	0.207	0.248		0.545	0.170	0.437
Sum Z	0.536	0.510	0.592	0.525	0.679	0.545		0.077	0.616
Exam	-0.119	0.041	0.059	0.080	0.021	0.170	0.077		0.833
Total	0.204	0.315	0.375	0.355	0.394	0.437	0.616	0.833	

Source: Authors

There are also correlation coefficients between points obtained in individual assignments (Z1 - Z6), the sum of points in assignments (Sum Z), points in the exam test (Exam) and the total sum of points (Total). These data are listed in Tables 3 and 4.

Table 4. Correlation coefficients between assignments in the group taught in English

	Z1	Z2	Z3	Z4	Z5	Z6	Sum Z	Exam	Total
Z1		0.487	0.250	0.023	-0.064	0.205	0.555	0.297	0.543
Z2	0.487		0.497	-0.038	0.047	0.231	0.717	0.289	0.645
Z3	0.250	0.497		0.005	0.079	0.428	0.684	0.015	0.459
Z4	0.023	-0.038	0.005		0.440	0.372	0.438	0.011	0.295
Z5	-0.064	0.047	0.079	0.440		0.186	0.461	0.174	0.407
Z6	0.205	0.231	0.428	0.372	0.186		0.620	0.092	0.463
Sum Z	0.555	0.717	0.684	0.438	0.461	0.620		0.263	0.816
Exam	0.297	0.289	0.015	0.011	0.174	0.092	0.263		0.772
Total	0.543	0.645	0.459	0.295	0.407	0.463	0.816	0.772	

Source: Authors

In a group of students studying in Slovak language most of the dependences are weak, i.e. they are in the interval <-1/3, 1/3>. Thus, the students' knowledge of solution of tasks in one assignment does not affect the solution of tasks in other assignments. There is also minimal dependence between the sum of points in the assignments and points in the exam. There were also cases when students had relatively many preliminary points in the semester and few points in the exam test or vice versa. A mean dependence was shown between the individual assignments and the sum of points in all assignments. Also a mean dependence was found between the number of points in assignments 3, 4, 5, 6 and the total sum of points in the semester; as well as between the sum of points in assignments and the total sum of points in the semester (0.616). A strong dependence appeared only between the number of points in the exam test and the total number of points (0.833).

In the case of students taught in English, there are slight differences in dependences. Mean dependences were shown between individual assignments (Z1 - Z2, Z2 - Z3, Z3 - Z6, Z4 - Z5 and Z4 - Z6). Mean dependences were also confirmed between individual assignments and the sum of points in all assignments, in two cases there is a strong dependence between assignment Z2 (Z3) and the sum of points in all assignments Sum Z. Between individual assignments and test points (similarly as in the group of students taught in Slovak) there is only a weak dependence, albeit a little higher. A mean dependence was found between individual assignments and the total number of points, except for the assignment Z4. The dependence between the sum of points in assignments and the points in the exam was also weak. Thus, the same conclusion was confirmed as in the group of students taught in Slovak: students gained relatively many points in the semester, but few points in the exam test or vice versa. This is evidenced by a strong dependence between the number of points in all assignments and the total number of points (0.816), as well as by a strong dependence between the number of points in the test and the total number of points (0.772).

By using the Mann-Whitney U test the authors tried to find out whether teaching of mathematics in English had an effect on students' achievements. They analyzed the following data: points in assignments, the sum of points in assignments and the points in the exam between the two groups of students (taught in Slovak and English). The ranges of the analyzed files satisfy, $m > 30$, $n > 20$, therefore the following test criterion was used (Markechová et al., 2011, p. 205):

$$U = \frac{U_1 - \frac{1}{2}mn}{\sqrt{\frac{1}{12}mn(m+n+1)}} \tag{1}$$

The tested null hypothesis at the level of significance α is rejected, if for the test criterion and the table value $|U| \geq u_\alpha = 1.9599$.

The results of the Mann-Whitney U Test (Table 5) show that between the two groups taught in Slovak and English there are no statistically significant differences between the total sums of points, the sums of points in the semester or the sums of points in the exam.

Table 5. Results of Mann-Whitney U Test (α = 0.05, 1.9599)

Assignment Slovak group	Assignment English group	*p*-value	u_1-value	$\|U\|$-value
Z1	Z1	0.897	1852	0.135
Z2	Z2	0.006*	1284.5	2.769*
Z3	Z3	0.165	1581	1.393
Z4	Z4	0.764	1816	0.302
Z5	Z5	0.031*	1414.5	2.166*
Z6	Z6	0.002*	1220.5	3.066*
Sum Z	Sum Z	0.184	1593.5	1.335
Exam	Exam	0.905	1854	0.125
Total	Total	0.516	1740.5	0.652

Source: Authors

From the analysis of six assignments, statistically significant differences were confirmed in three cases between the English and Slovak groups. The assignments Z2 and Z5 were better done by students from the Slovak group; the assignment Z6 was better done by students from

the English group. In both research groups it was shown that students were motivated during the semester to obtain the required number of points to get the credit, but in the exam their motivation decreased; many of them were satisfied with the final evaluation E(3).

4. CONCLUSION

The pandemic situation with COVID-19 has closed down the universities in order to protect students and teachers, and the process of education continued in virtual space. New teaching and learning conditions have affected the education methods and new procedures were required for evaluation of students' knowledge. In the paper the authors analyzed data obtained from teaching Mathematics IA in the 1st year of bachelor's degree at the Faculty of Economics and Management, where one research sample consisted of students taught in Slovak and the other sample consisted of students taught in English. The authors used the correlation coefficient and the Mann-Whitney U test to identify significance of differences between points obtained in mathematical assignments and exam tests. In the Slovak group, results showed a strong correlation between the number of points in the exam test and the total number of points (0.833). In the group taught in English a strong correlation appeared between the number of points in the exam test and the total number of points (0.773). Another strong correlation was confirmed between the total number of points and the sum of points in all 6 assignments during the semester (0.816). Obtained results will be used to update the teaching of mathematics during distance education at the Slovak University of Agriculture in Nitra. The intention of teachers in the innovative environment is that students acquire the necessary mathematical knowledge and skills that will increase their motivation for the study of mathematical subjects and achieve better evaluation in exams.

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