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Original Pap

Verification mathematics knowledge of students at Faculty of Engineering SUA in Nitra

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ABSTRACT

In our paper we evaluated and compared the results that achieved by the students of the Faculty of Engineering of the Slovak University of Agriculture (SUA) in the school year 2022/2023 during the semester with the results written examination papers. Intermediate, necessary for credit, verification of mathematical knowledge and skills we were made in the form of independent homework, the final examination written work was held place in person on the campus of our university. At evaluation of the obtained data we used the methods of mathematical descriptive statistics, we calculated the average scores of individual components and total scores, which we entered into tables. We also calculated correlation coefficients, which we used to determine whether the learning of one part of mathematical knowledge has an effect on the mastery of another. We found that for home the students scored a higher percentage of points for homework than for homework face to face at school, which is probably natural and expected.

KEYWORDS: verification of mathematical knowledge, independent homework, evaluation of obtained data

JEL CLASSIFICATION: C02, C11, I210

INTRODUCTION

Following the discovery of a new species of coronavirus at the end of 2019, a new situation has arisen worldwide. There have also been changes in education at all levels of schools, primary, secondary, and higher education. At our university, we switched to distance education after some time, later it was combined (online lectures, face-to-face exercises). In the last school year, teaching is now "normal", i.e. full-time, except for the external form, which has remained combined. For many students and teachers, the digital form of learning has been creative and inspiring. That is why we have also decided to address at least part of

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the teaching in this form. Lectures, exercises, and final exams were conducted directly, in contact, and we did continuous knowledge verification remotely.

Cígler (2018) 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). Álvarez (2018) states that mathematics plays a key role in every engineer's curriculum because it provides the theoretical foundation for various science theories. Országhová et al. (2013) state in their work that mathematical knowledge becomes permanent only if students sufficiently understand mathematical concepts with their logical meaning and process them appropriately. In his work, Hailikari (2009) examined how different types of prior knowledge affect student achievement and how different assessment methods affect the observed impact of prior knowledge. In their article, Gamage et al. (2022) examine the procedures used in both closed- and open-book examinations and identify the challenges associated with moving to online examinations. It also identifies potential ways forward for future online exams while minimizing opportunities for student collaboration, plagiarism, and use of online materials. Also George D. Kuh et al. (2014) addressed the current state of student learning outcomes and their assessment in U.S. colleges and universities. Pechočiak and Kecskés (2016) say that the use of mathematical and statistical methods not only enables the detection of the occurrence of certain phenomena in the new global environment, but indirectly requires special attention. The statistical analysis of mathematical and linguistic competences has also been addressed by Országhová and Horváthová (2015). In conclusion, we do not forgive the quotation of Rozhkova et al. (2017): 'Mathematics is more than a natural science, it is the language of all sciences'.

MATERIAL AND METHODS

In our work we decided to evaluate the knowledge and skills acquired by the students of the Faculty of Engineering of the Slovak University of Agriculture in Nitra in the course Mathematics for engineers, which is taken by students in the summer semester of the first year. Comparison of exam results in Mathematics was also addressed by Matušek and Hornyák Gregáňová (2019).

As mentioned above, teaching in this school year (2022/2023) was full-time. We have given a lot of thought to how we would conduct ongoing verification of the knowledge and skills acquired by students during the semester. We found that students do not know how to learn mathematics continuously (or do they not want to?). We have decided to send students assignments which they study and work out at home independently, with enough time. Each student had different kinds of examples so that they could not send their solutions to each other. During the semester, students were thus asked to produce four separate assignments, each containing 2 problems, and one term paper. Of course, the material had been previously lectured and practiced in the exercises. In the first assignment, we wanted to find out what the students had learned about functions, what they are called, what their graph is, what properties they have, and whether they could find out their defining region or the inverse function to them. We give an example of such an assignment:

1. What is the name of the function $f: y = 2x^2 - x - 3$, what is its graph called and sketch it. Write at least 3 properties.

2. Determine the defining region D_g of the function $g: y = \log \frac{5-x}{3+x}$.

After reviewing the subsection on derivatives of functions and calculating properties of functions of one variable using derivatives, students were given a second assignment to work on. Here is an example of such assignments:

1. Calculate the derivative of the function $y = \frac{5x+4}{3-2x}$.
2. Find the concavity intervals of the function $f: y = x^4 + 6x^3 + 12x^2 - 2x + 6$.

In the third assignment, students had to work out problems from the topic function of two variables. In the first task they calculated the second partial derivatives of a given function, in the second task they either found the local extrema of a function of two variables but calculated the equation of the tangent plane to a given surface. We present one such assignment:

1. Calculate the second partial derivatives of the function $z = \frac{2y-3x}{4x}$.
2. Find the local extrema of the function $z = xy - 2x + 5y - 12$.

In the fourth problem, students were calculating an indefinite and a definite integral, one of which they had to calculate by the substitution method and the other by the per partes method, but we did not tell the pupils which of these problems was solved by which method. An example of such an assignment is below:

1. Calculate $\int \frac{3x}{\sqrt[3]{2+x^2}} dx$.
2. Calculate $\int_0^{\frac{\pi}{2}} 4x \cos x dx$.

Students could earn 5 points for each example in each problem, i.e. 10 points for the entire assignment.

The term paper consisted of 3 parts. In the first part, students had to sketch a picture of an area bounded by 2 functions, one always linear (graph is a line) and the other quadratic (graph is a parabola) and calculate the x-coordinates of the intersections of these figures. In the second part, students calculated the volume of this surface, and in the third part, they calculated the volume of the rotating solid that was created by rotating this surface about the x-axis. They could earn 5 points for each part, or 15 points for the whole paper. An example of two such functions is given: $f: y = 9 - x^2$ and $g: y = x + 3$.

Students were allowed a total of 55 points, four times 10 points each for assignments and 15 points for the term paper. They needed a minimum of 30 points to receive credit, which is 54.54 % of those points. If a student did not receive credit, they would have the opportunity to write make-up credit papers. However, this option did not occur this school year, so all students had a minimum of 30 points. This allowed students on probation to register for the exam. The examination work was written, held on the school premises. It consisted of 5 examples from the whole-semester syllabus, for each example the student could get 10 points, i.e. 50 points in total. There were 60 minutes to complete it. In addition to the problems that students solved in individual assignments and term papers, there was also a thematic unit on differential equations, which was of course lectured and practiced. Here is a sample of such work:

1. Determine the defining region D_f and the inverse function f^{-1} to the function $f: y = 3 - 4\log_5(5x-2)$.
2. Calculate the monotonicity intervals of the function $g: y = x^3 - 3x^2 - 24x + 5$.
3. Solve the equation $y^{IV} = 2x^2 + 3$.
4. Calculate the second partial derivatives of the function $z = 2x + 5y^2 - 3x^2y^3 + 4\cos x - 7$.
5. Solve the equation $4y \cdot y' = 2x^3 - 4$.

We added the points earned by the student during the semester with the points earned on the exam paper, and the maximum number of points earned in this way was 105. We determined the exam grade using the ECTS scale:

A(1) - excellent : 93 – 100 %
B(1,5) - very good : 86 – 92 %
C(2) - good: 79 – 85 %
D(2,5) - satisfactory: 72 – 78 %
E(3) - sufficient : 64 – 71 %
F(4) - fail : ≤ 63%

As it follows from this scale, to be successful in this course, a student had to score a minimum of 64 points.

We created a database in Excel from the scores that students earned over the course of the semester for individual assignments, term papers, and exam written work. Excel is a Microsoft spreadsheet designed for the Microsoft Windows operating system. Along with Word and PowerPoint, it is part of the Microsoft Office suite. We have the 2016 version available. In evaluating the data, we also used insights from the textbook by Markechová et al. (2011), especially the methods of mathematical descriptive statistics. From the collected data we calculated the average points score for each assignment, the term paper, the exam written work and the total score. We also calculated the correlation coefficients between the scoring components. Using these, we wanted to see if there was any dependency between them. That is, whether if students master one part, the thematic unit, they also master the others.

RESULTS AND DISCUSSION

In the summer semester of the school year 2022/2023, 82 students started studying in the groups we monitored. Some students had already dropped out during the semester for reasons not identified. Two did not pass the exam, i.e. did not obtain a total of at least 64 points for the midterm papers and the exam written work. Three students have not yet appeared for the examination. This means that 58 students have passed the Mathematics for Technicians course this school year.

As noted above, students could earn 55 points during the semester (four times 10 points each for assignments and 15 points for the term paper) and 50 points for the exam written work.

We have compiled the data in Table 1. It shows the average number of points that students received for each unit of the course, the maximum number of points they could have received (full points), and the percentage of points received to all possible points. **Ai,** $i = 1, 2, 3, 4$ are the points for the individual assignments, **TP** are the points for the term paper, **EX** are the points for the exam and **C+EX** are credit points and exam points.

Table 1 Number of points obtained by students during their studies

	A1	**A2**	**A3**	**A4**	**TP**	$\sum \mathbf{Ai + TP}$	**EX**	$\sum \mathbf{C + EX}$
Average	8.97	8.07	8.07	8.86	13.03	47.00	29.76	76.76
Full points	10	10	10	10	15	55	50	105
%	89.66	80.69	80.69	88.62	86.90	85.45	59.52	73.10

Source: own

As we can see, students scored above 80% for each assignment, the least for assignments 2 and 3 (derivatives and their applications of one and two variables), averaging 8.07 points, and the most for properties of functions, averaging almost 9 points. For the term paper, they received an average of 13.03 points, nearly 87% of the possible points. In total, they scored an average of 47 points for the term papers, representing 85.45% of the total possible points. The written test paper fared worse, with an average score of 59.52%, less than 30 points out of 50. This was reflected in the final grade, which averaged at the lower end of the ECTS D scale, which was 73.1%, or 76.76 points out of 105. Table 2 shows the distribution of the numbers of students according to the final grade they obtained according to the ECTS scale.

Table 2 Number of final assessments according to the ECTS scale

	A	**B**	**C**	**D**	**E**
Number of ratings	0	12	10	14	22

Source: own

It is striking that 24 students scored 50 points or more during the semester, four of whom scored the full 55 points, but did not write the exam paper to earn an A grade; even two of them settled for an E grade.
In Figure 1, we have shown what the ratio between the points needed for credit (for assignments and term paper) and the exam paper should have looked like and what it actually was.

Figure 1 shows that during the semester, a student could score 55 points for 4 short credit essays and a term paper and 50 points for an exam written paper, for a total of 105 points. In theory, the ratio of credit and exam points was 52.4 : 47.6. In reality, however, students had this ratio of 61 : 39.

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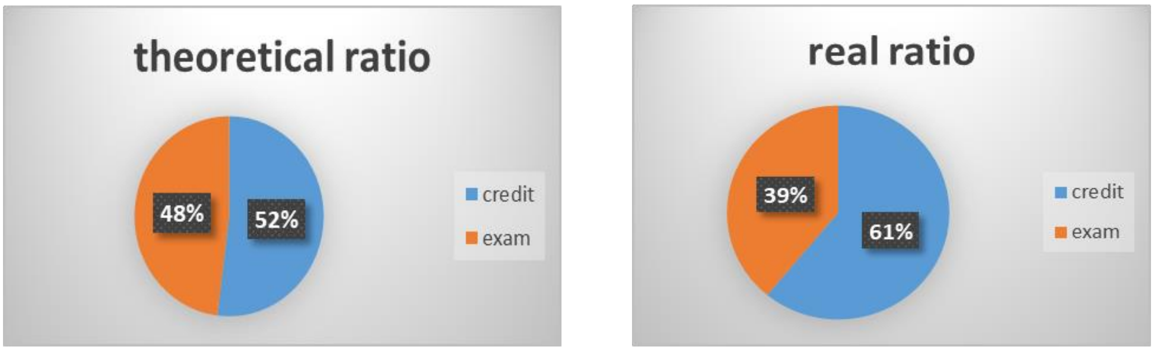

Figure 1 Ratio between semester and exam scores (theoretical and real)
Source: own

In the next part of the paper, we computed the correlation coefficients between the individual components. We wanted to find out whether it has an effect that if a student knows (or does not know) how to calculate one part of a given subject unit, he/she also knows (or does not know) how to calculate the other part. A strong dependence occurs if the correlation coefficient is intervals $\left\langle -1,-\frac{2}{3}\right) \cup \left(\frac{2}{3},1\right\rangle$, 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 weak dependence is if the correlation coefficient is from the interval $\left\langle -\frac{1}{3},\frac{1}{3}\right\rangle$. We have written the calculated coefficients in Table 3.

Table 3 Correlation coefficients between point items

	A1	A2	A3	A4	TP	EX
A1		0.235	0.237	0.144	-0.163	0.072
A2	0.235		0.281	-0.080	0.087	0.362
A3	0.237	0.281		0.134	0.107	-0.052
A4	0.144	-0.080	0.134		0.332	0.258
TP	-0.163	0.087	0.107	0.332		0.110
EX	0.072	0.362	-0.052	0.258	0.110	

Source: own

As Table 3 shows, almost all dependencies are weak. Thus, whether or not a student can solve problems from an assignment, term paper or exam paper does not affect the solution of other problems. The only medium dependency, even at the lower bound, was between the second assignment and the exam written work. We also calculated the correlation coefficient between the sum of points earned during the semester (required for credit) and the exam written paper. This too was low, only 0.245. This confirmed that the number of points earned during the full-time coursework did not affect what final grade a student would eventually receive, as we mentioned above. The only strong dependence (0.743) was confirmed between the sum of the points obtained during the semester and the total points including the exam paper, which is probably to be expected.

CONCLUSIONS

Almost 70% of the students who started their studies at the Technical Faculty of the Slovak University of Agriculture in the school year 2022/2023 have successfully completed their studies. This is not an unusual figure for studies in engineering. This school year, we have decided to test the knowledge and skills acquired during our studies in the subject Mathematics for engineers in a so-called combined form. We gave the students 4 short, two-task assignments, and a term paper to do at home. In this way they were able to score a total of 55 points. On average, they succeeded in doing so by more than 85%.

The exam written work was already contact work, on the university premises, for 50 points, from which the students scored an average of just under 30 points, giving a success rate of roughly 59.5%. The overall pass rate was 76.76 points on average, representing a 73.1% pass rate. We think that this overall success rate is relatively small because students did perform well throughout the semester, but this was because they had a longer time, a week, to work them out and they could also help themselves with lecture notes and exercises. It appears to us that the students are not able to learn mathematics continuously (or do they not want to?). We assume that this was also caused by the prolonged interruption of "normal" contact teaching during the coronavirus pandemic. If we switched to doing all assignments continuously in the classroom, we anticipate that the success rate would be very low, and students would struggle to pass the course.

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