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Original Paper

Education of mathematics during the coronavirus crisis

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ABSTRACT

At the turn of 2019 and 2020, after the emergence of a new type of coronavirus, a new situation arose worldwide. This crisis has also caused changes in education at all levels schools in Slovakia. Primary schools, secondary schools, but also universities had to transfer their teaching from buildings to online space. We switched to distance education. We were forced to develop a number of new digital teaching aids, both in the form of Word texts, but also animated and spoken Power Point lectures. We also used the prepared lectures, which we found on the Internet. After the study materials presented and distributed in this way, we also performed a retrospective check of the acquired knowledge by the students. It was the elaboration of written works by students in individual study units, but also seminar works, credit and exam works. Students received points for each work submitted in this way. By adding the points obtained in this way, the students were awarded a total mark according to the ECTS credit scale. In our paper, we also deal with the evaluation of points obtained by students. We found out whether mastering individual knowledge had an impact on the control of others and how it affected the overall evaluation of the student.

KEYWORDS: coronavirus crisis, education of mathematics, distance education, points earned, correlation coefficient

JEL CLASSIFICATION: C02, C11, I210

INTRODUCTION

Digital technologies are changing our daily lives at a tremendous pace and have, of course, become an integral part of it. Since the beginning of this century, the digital revolution has been talked about in the world and in our country. Today, most of us cannot imagine life without mobiles, tablets, computers and, of course, the Internet. The Internet has become a source of information. Electronic communication and access to information have become part

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of many areas of life. For this reason, it is necessary to focus not only on classical education, but also on education using information technology.

By 2020, the European Union has set aside € 50 billion for such education. The countries where IT research programs are most developed are China, the USA and Switzerland.

At the end of 2019, a new type of coronavirus appeared in China. As today's world is globalized, including tourism, it soon moved from China to Europe and the rest of the world. He appeared with us at the beginning of March. After the closure of all types of schools, whether primary, secondary, but also universities and colleges, these schools were forced to move their teaching from buildings to online space. This crisis has forced us to move to distance education. For many teachers, but also for pupils and students, the digital form of education was so inspiring and creative that their knowledge progressed.

The summer semester of the school year 2019/2020 started normally. 4 weeks of teaching, ie lectures and exercises took place in contact. Due to the increase in the number of people infected with the coronavirus in Slovakia, the management of our university decided on March 9, 2020 to interrupt contact teaching for 2 weeks, with the proviso that we had to assign students to work for self-study. As the situation with the corona crisis did not calm down after this period, we had to "transfer" the teaching to the online space. We had to think about how we would continue teaching, how we would make new knowledge available to students and how we would verify how they acquired it. As stated in [3], mathematical knowledge becomes permanent only if students sufficiently understand the mathematical concept and its logical meaning and process it appropriately. An important part of the explanation is also the visualization of the curriculum, which facilitates it and can shorten the learning process [1]. Rumanová and Drábeková also dealt with this topic [6].

MATERIAL AND METHODS

In the summer semester of the school year 2019/2020, we taught the subject Mathematics for Technicians at the Faculty of Engineering of the Slovak University of Agriculture in Nitra. We will introduce the thematic areas of this subject (after the 5th point they are identical with the "normal" teaching, from the 6th point they are modified, simplified):

1. **Function of one real variable**
   Definition a function of one real variable. Definition area and area of function values, function graph. Elementary functions. Basic properties and graphs. Inverse functions.
2. **Differential calculus of the function of one real variable**
   Derivation rules. Derivatives of sum, difference, product and proportion of functions, derivation of a compound function. Formulas for deriving elementary functions.
3. **Use of derivation**
   Monotony of the function. Intervals of convexity and concavity of a function. Extremes of a function, inflection points of a function.
4. **Applications of derivatives**
   Investigation of the course of the function. Touch to the graph of a function.
5. **Function of two real variables**
   Definition of a function of two variables. Definition area, graph of a function of two variables. Partial derivatives. Higher order partial derivatives.

6. Indefinite integral
Indefinite integral from polynomial function and indirect level.
7. Definite integral - Newton-Leibniz theorem.
8. Use of a definite integral
Content of a planar formation, volume of a rotation solid.
9. Differential equations
Differential equations 1st order separated and separable. Higher order differential equations for which the order can be reduced by integration.

Contact lessons took place in the first 4 weeks, on Monday the 5th week we still had a lecture. Thus, the students had lectured the first five thematic units from the given schedule and practiced the first three units. Although lectures are compulsory, not all students attend them, for a variety of reasons. Therefore, we developed a detailed procedure for students to calculate partial derivatives in Word. We drew on these and other materials from textbooks [5] and [2], which we wrote together with colleagues from our department. After a week, we gave them materials for credit written work, which were also planned at this time. Each student received their assignment with 3 examples, which they had to work out and send back in the allotted time. He could get a maximum of 30 points for it. We will give an example of assigning such a work:

1. Calculate the definition area D_f and the inverse function f^{-1} to the function $f: y = 4 + 5\log_3(2x-3)$.
2. Calculate the monotonicity intervals of the function $g: y = 3x^4 - 4x^3 - 36x^2 + 7$.
3. Calculate the second partial derivatives of the function $h: z = 3x^4y^3 + 5x^2y^5 - 2x^2 + 7y + 6$.

The following week, we sent students links to freely accessible pages on YOUTUBE with lectures on the topic of indefinite and definite integral. Students could get two points by manually writing formulas for derivatives and integrals of functions and sending them to us in front of them. To verify whether they learned to compute integrals using such lectures, we sent them assignments of 4 examples, for which they could get 7 points (1st example 1 point, next 2). We present them:

1. Calculate $\int (3x^5 - 6x^3 + 4x - 5)dx$.
2. Calculate $\int \left(\frac{5}{x} + 7\sqrt[4]{x^3}\right)dx$.
3. Calculate $\int_1^3 (4x^3 + 3x^2 - 4x - 3)dx$.
4. Calculate $\int_0^{\frac{\pi}{2}} (2\sin x - 4\cos x)dx$.

Then we sent them sample examples for home seminar work, which concerned the calculation of the contents of planar structures and volumes of rotation solids. They could get 15 points for the work. We present the assignment of such work:

a) Sketch an image of the area bounded by curves $f: y = 2x + 4$ and $g: y = x^2 + 1$ and calculate the *x*-coordinates of the intersections of these curves.
b) Calculate the content of this area.
c) Calculate the volume of the rotation solid created by rotating this surface around the *x*-axis.

Finally, we are left with the last topic: differential equations. We have prepared a separate lecture on this topic using the OSB studio program. We used an animated POWER POINT presentation, which we verbally commented on. For verification, we again sent students an assignment of 3 examples, for which they could get 6 points. Here are some examples:

1. Solve the equation $3y^3y' - 5x^4 = 0$.
2. Solve the equation $\frac{5}{y^2} + 4xy' = 0$.
3. Solve the equation $y^{(4)} = 2x^2 + 3$.

In total, students were able to obtain 60 points, while they needed at least 30 points to be awarded the credit. Those who received the credit could prepare a written test. With less than 30 points, we made it possible to write corrective credit papers. The exam work consisted of 5 examples from the whole semester curriculum, while students could get 50 points for it. It took 120 minutes to complete and submit. Here is an example of such work:

1. Specify the definition area of the function $f: y = \sqrt{\frac{3x}{4-x}}$.
2. Calculate the derivative of the function $y = \frac{2\ln x}{3+2x}$.
3. Calculate the second partial derivatives of the function $z = 2xy^3 + 4x^3y^2 - 3\ln y - 5$.
4. Calculate the integral $\int_{-1}^{2} \left(2x^3 + 6x^2 - 5\right)dx$.
5. Calculate the equation $\frac{2}{y^2} + 4x^3y' = 0$.

We awarded the final grade after adding up all the points that the students could get during the whole semester. We used the ECTS scale for evaluation:

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)
≤ 63% – fail – FX(4).

In the next part of the work we evaluated the results obtained by students in this form of study. We used the method of mathematical descriptive statistics for this. From the obtained data, we created databases in Excel by arranging the results of individual parts of this course for each student from each group below each other. From these data, we calculated the average score of the individual components and the number of points for each student. We also found out the correlation coefficients between the individual parts of this course, for which students could get points, ie whether it applies, if students master one part, they manage others, that is, whether there is any dependence between them. Similarly, we addressed the role in the paper [4]. 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 $\left\langle -1, -\frac{2}{3} \right) \cup \left(\frac{2}{3}, 1 \right\rangle$.

RESULTS AND DISCUSSION

At the beginning of the summer semester, 83 students started studying in my groups. During the semester, 9 students completed their studies due to failure to do this and other subjects, or for unknown reasons. So 74 students successfully completed the subject Mathematics for Technicians. As we mentioned above, students could get 30 points for credit written work, 7 points for calculating integrals, 2 points if they wrote and sent me formulas of derivatives and integrals of selected functions, for seminar work they could get 15 points, for calculating differential equations 6 points and 50 points for a correctly calculated exam written work.

In Table 1, we present the number of points for the individual units of the subject, ie the full number of points that the students could get, the average number of points that they received and their percentage. As we can see in the table, the best students wrote the credit work, at 83.15%, then the seminar work, at 81.26% and the exam work at 76.22%. They wrote the worst control work on differential equations, only at 60.59%. The average sum of points obtained was 85.3 points, which represents 77.54% of the total number of 110 points.

Table 1 Points obtained during the semester and their sum

	CWW	ECI	FDI	SW	ECDE	SPODS	POEW	TP
FNP	30	7	2	15	6	60	50	110
ANP	24.95	5.01	1.41	12.19	3.64	47.19	38.11	85.30
ANPP	83.15	71.62	70.27	81.26	60.59	78.65	76.22	77.54

Source: own

Explanations of the abbreviations in the table:
CWW - credit written work
ECI - examples for calculating integrals
FDI - formulas of derivatives and integrals
SW – seminar work
ECDE - examples for calculating differential equations
SPODS - the sum of points obtained during the semester
POEW - points obtained of the exam work
TP - total points
FNP - full number of points
ANP - average number of points
ANPP - average number of points in percent

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In the next part of the research, we calculated the correlation coefficients between the individual components of the subject. We wanted to find out whether if a student can (or does not know) calculate one part of a given thematic unit, he can (or does not know) calculate another. We wrote these coefficients in Table 2.

Table 2 Correlation coefficients between the points obtained individually and their sums

	CWW	ECI	SW	ECDE	SPODS	POEW	TP
CWW		0.0017	-0.0165	0.1785	0.6082	0.1045	0.4653
ECI	0.0017		0.3381	0.3665	0.5393	0.0193	0.3600
SW	-0.0165	0.3381		0.2471	0.6658	-0.0952	0.3592
ECDE	0.1785	0.3665	0.2471		0.5960	0.2621	0.5704
SPODS	0.6082	0.5393	0.6658	0.5960		0.0807	0.6998
POEW	0.1045	0.0193	-0.0952	0.2621	0.0807		0.7685
TP	0.4653	0.3600	0.3592	0.5704	0.6998	0.7685	

Source: own

The description of the abbreviations in Table 2 is the same as in Table 1.

The highest dependence (0.7685) was confirmed between the points for the exam work and the total sum of points, a slightly smaller but still strong dependence (0.6998) between the sum of points obtained by the students during the semester and the total sum of points. Both of these addictions were to be expected. The mean dependence was shown between the individual components that the students worked on during the semester and the sum of the points thus obtained, but also the total number of points. There was a weak dependence between the individual components and their sum in comparison with the test written work. We explain this by the fact that students gained an average of 47.19 points per semester, which represents 78.65% of the total possible number of points, and they thought that they no longer have to prepare so much for the exam, because they have a sufficient number of points. It so happened that the student received almost the full number of points for the semester and after adding up the points for the exam written work, he received only the evaluation sufficient – E (3).

CONCLUSIONS

The coronavirus crisis forced us and taught us to make changes in education. We led the teaching process in other, distance ways. We have developed a number of new digital teaching aids, lectures and instructions for practicing their curriculum. In this way, we also checked the students as they studied new mathematical knowledge and skills. We are glad that we, teachers, but also students have mastered this form of study. After all, almost 90% of enrolled students successfully completed the subject Mathematics for Technology, and this number could be even higher if we knew the reason for not continuing the study for some students. We hope that such a situation will not last long, because after all, contact teaching, especially in a subject such as mathematics, is probably more positive for most students and they themselves prefer it to the distance form.

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REFERENCES

[1] Drábeková, J. & Čeryová, D. (2016). Geogebra and several economic applications of learning curve. *Proceedings of the conference Didmattech 2016*. Retrieved 2020-08-18 from http://didmattech.inf.elte.hu/wp-content/uploads/2016/08/DJ_CD_Geogebra.pdf

[2] Országhová, D., Farkašová, M., Hornyák Gregáňová, R., Pechočiak, T., Matušek, V., Kecskés, N. & Drábeková, J. (2019). *Mathematics with applications.* 1st ed. Slovak University of Agriculture in Nitra. 209 p. (in Slovak).

[3] Országhová, D., Gregáňová, R. & Matušek, V. (2013). *To the current mathematical competencies in higher education in economic and technical fields of study.* 1st ed. Slovak University of Agriculture in Nitra. 141 p. (in Slovak).

[4] Pechočiak, T. & Kecskés, N. (2016). Integral calculus at technical universities. *Mathematics in education, research and applications.* (2), 1, 36-40. doi: http://dx.doi.org/10.15414/meraa.2016.02.01.36-40

[5] Pechočiak, T. & Matušek, V. (2012). *Chapters from higher mathematics*. 1st ed. Slovak University of Agriculture in Nitra. 196 p. (in Slovak).

[6] Rumanová, L. & Drábeková, J. (2019). Visual understanding of problem and pictures' occurrence in educational process. *TEM JOURNAL - technology, education, management, informatics.* 8, 1 (2019), pp. 222-227.

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Original Paper

Regression analysis of expanded polystyrene properties

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ABSTRACT

Own measurements examine the tensile strength of expanded polystyrene (EPS) depending on its bulk density. 30 samples were used to calculate the correlation coefficients between these two properties. In addition to the standard Pearson coefficient, we also calculate the rank correlation coefficients, Spearman´s and Kendall´s. By testing the hypotheses, we verify the correlation of the entire population. After finding a relatively close correlation (0.6 - 0.8), we apply different regression models, especially polynomial, but also exponential. We evaluate the properties of parameters in models, their point estimates and confidence intervals. Based on the characteristics of each of the seven regressions, we found the best exponential form of the dependence, before the linear polynomial. The complexity of a mathematical model does not always mean that it is also a more accurate approximation. On the other hand, a simple model makes it possible, in addition to its ease of use, to more closely reflect the examined dependence.

KEYWORDS: Expanded polystyrene (EPS), bulk density, tensile strength, correlation, regression model

JEL CLASSIFICATION: C12, C13, C15

INTRODUCTION

Expanded polystyrene (EPS) is a proven heat-insulating, but also sound-insulating material. It is lightweight and has a bulk density, which makes it easy to process [4]. Sometimes its strength properties can be used and therefore it is appropriate to measure its tensile strength [2]. The interdependence between density and strength of EPS is presented by many distributors [8], [11]. To determine the intensity of this relationship, it is advantageous to apply a correlation analysis [1]. A mathematical description of such dependence can be provided by regression analysis, which has a number of characteristics evaluating every regression model [14]. It is then important to evaluate these values correctly, so that we do not

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have to rely on subjective judgment, but we were able to classify the suitability and unsuitability of the chosen mathematical formula by comparing specific numbers.

MATERIAL AND METHODS

Expanded polystyrene (EPS) - properties

Expanded polystyrene (EPS) is an organic matter that belongs to a group of foam plastics. It is made from the chemical substance styrene, which is expanded (foamed) with water vapor and blowing agent (pentane). Industrial styrene and pentane are extracted from petroleum, although they are also commonly found in nature. EPS is one of the most widely used plastics, right after PVC, polyethylene and polypropylene. The highest rated properties of polystyrene are its excellent thermal insulating properties, easy workability due to its low bulk density and affordability.

EPS foam matter consists of about 2% polystyrene and 98% air. It is actually engineered wrapped air and it causes its excellent insulating ability. It has high compressive, tensile and flexural strengths that increase linearly with increasing bulk density. Its low weight reduces the load on the load-bearing structure, the transport costs and the effort in use. EPS is not soluble in water and therefore its cells do not absorb water into its structure, causing its very low water absorption. It can only absorb water vapor to a certain extent and therefore it is important to ensure that the dew point is not inside the polystyrene structure for a long time. Polystyrene products have been used for many years for food packaging, which is evidence of their health safety. The rapid development of the use of EPS as thermal insulation has necessitated the development of so-called self-extinguishing polystyrene, which meets the strict requirements for fire protection of buildings. Polystyrene as thermal insulation reduces fuel consumption, making it very environmentally friendly. Last but not least, EPS production is also ecological and polystyrene is also recyclable.

In construction, EPS is applied primarily for thermal insulation, but also for sound insulation. It can be used to create various decorative or shaping elements, for air filling or for foundation of traffic constructions on soft soils. Everyone has already encountered the purpose of polystyrene as a packaging material, and thus the field of application is far from over.

The extensive use of expanded polystyrene was the main motivation for us to determine the tensile strength of EPS and the corresponding density. The tests were performed on a jaw tear machine and a bulk density was determined for each sample [7], [9], [10].

Correlation coefficients and correlability

The correlation analysis examines the relations between random variables, the most important being the intensity of interdependence. The result of this examination is a correlation coefficient r, which takes values from -1 to +1. Values close to -1 or to +1 indicate a strong correlation and values close to 0, on the contrary, weak, respectively. no correlation. The Pearson correlation coefficient is calculated from the relationship

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$$r = \frac{Cov(x,y)}{\sqrt{Var(x)}.\sqrt{Var(y)}} = \frac{\overline{x.y}}{\sqrt{\left(\overline{x^2} - \overline{x}^2\right)}.\sqrt{\left(\overline{y^2} - \overline{y}^2\right)}} \qquad (1)$$

where Cov(x,y), Var(x), Var(y) are covariance and variance of measurements of the variables x, y and the bar above the value of the variable denotes its mean value. An assumption for applying the coefficient (1) is a linear relationship between the variables x, y and their normal probability distributions.

The sensitivity to extreme values does not show rank correlation coefficients. Nor do we need assumptions about the types of measurement distributions or about the linear dependence between variables. The Spearman rank correlation coefficient is calculated from the formula

$$r_S = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n.\left(n^2 - 1\right)} \qquad (2)$$

where $d_i = R_i^x - R_i^y$, i = 1, 2, …, n, are the differences between the order numbers R_i^x and R_i^y and n is the number of observations. As can be seen from the relation (2), instead of the values of the measured quantities, we assume their order in the set.

The Kendall rank correlation coefficient is expressed in the form

$$r_K = \frac{c - d}{\sqrt{c + d + x_{extra}}.\sqrt{c + d + y_{extra}}} \qquad (3)$$

where $c = \Sigma c_i$ and $d = \Sigma d_i$, are the sums of the concordant and discordant orders between the independent variable x and the dependent y, x_{extra} and y_{extra} represent the number of variables with the same order.

The sample correlation coefficients *r* are point estimates of the correlation coefficient ρ of the population. Therefore, nonzero r does not mean that ρ will be nonzero too. The importance of testing the hypothesis H_0: Random variables are uncorrelated ($\rho = 0$), compared to the alternative hypothesis H_1: Random variables are correlated ($\rho \neq 0$), comes to the fore especially in the case of a small number of measurements. This test can be performed for all three types of described correlation coefficients (Pearson, Spearman, Kendall) and is most often carried out at a significance level of $\alpha = 0.05$. Refer to the literature for further details [5], [6].

Regression analysis

While the correlation analysis determines the existence and intensity of the dependence between variables, the regression analysis looks for the form of this dependence. The general form of the linear function in the parameters is written

$$y = f(x) = \sum_{j=0}^{k} a_j . \varphi_j(x) \qquad (4)$$

where a_j are parameters, constants and $\varphi_j(x)$ are functions of independent variable that no contain already other parameters [6]. The point estimation of parameters a_j most commonly uses the least squares method, which minimizes the sum of squares for error (SSE)

$$SSE=\sum_{i=1}^{n}\left(y_i-\hat{y}_i\right)^2=\sum_{i=1}^{n}\left(y_i-\hat{a}_0\varphi_0(x_i)-\ldots-\hat{a}_k\varphi_k(x_i)\right)^2 \tag{5}$$

y_i, i = 1…n, are obtained values of the dependent variable, $\hat{y}_i$, i = 1…n, are the estimated values by the regression function and $\hat{a}_j$, j = 1 … k are the estimated values of the parameters. In the confidence intervals of parameters a_j the Student distribution with n-k-1 degrees of freedom is applied.

By means of SSE it is possible to determine the mean squared error (MSE) and simultaneously root mean squared error (RMSE)

$$MSE=\frac{SSE}{n-k-1} \qquad RMSE=\sqrt{MSE} \tag{6}$$

When we use the least squares method, the relationship must hold

$$SST = SSR + SSE \tag{7}$$

where

$$SST=\sum_{i=1}^{n}\left(y_i-\overline{y}\right)^2$$
$$SSR=\sum_{i=1}^{n}\left(\hat{y}_i-\overline{y}\right)^2 \tag{8}$$
$$SSE=\sum_{i=1}^{n}\left(y_i-\hat{y}_i\right)^2$$

SST is the total sum of squares and SSR is the sum of squares for residuals, further denotation is explained above. According to (7) it must therefore apply

$$\sum_{i=1}^{n}\left(y_i-\overline{y}\right)^2=\sum_{i=1}^{n}\left(\hat{y}_i-\overline{y}\right)^2+\sum_{i=1}^{n}\left(y_i-\hat{y}_i\right)^2 \tag{9}$$

Coefficient of determination R^2 is called the ratio

$$R^2=\frac{SSR}{SST}=\frac{\sum_{i=1}^{n}\left(\hat{y}_i-\overline{y}\right)^2}{\sum_{i=1}^{n}\left(y_i-\overline{y}\right)^2} \tag{10}$$

which takes the values $0 \le R^2 \le 1$. It determines that part of the total variability of the observed values that can be explained by the regression model. For small sample sizes n, a modified coefficient of determination R^{*2} is used due to the bias of the estimate

$$R^{*2}=R^2-\left(1-R^2\right).\frac{k}{n-k-1} \tag{11}$$

The regression model as a whole can be tested for the significance of the coefficient of determination R as well as of all regression coefficients with the exception of the absolute coefficient a_0. At the selected significance level α we test the hypothesis H_0: $a_1 = a_2 = \ldots = a_k = 0$, i. e. the regression model is statistically insignificant compared to the alternative hypothesis H_1: at least one of the regression coefficients $a_1, a_2, \ldots, a_k \neq 0$, i. e. the regression model is statistically significant.

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RESULTS AND DISCUSSION

Obtained values of bulk density and tensile strength are given in the Tab. 1. We performed 30 measurements, which we statistically evaluated on the boxplots in the Fig. 1. The interdependence of both sets was estimated by different types of correlation coefficients in the Tab. 2. Their values are positive and relatively high, which represents a direct dependence between quantities. As mentioned above, it is appropriate to verify the mutual correlability with the hypothesis H_0: $\rho = 0$, at the significance level $\alpha = 0.05$. Values of p in the second line of the Tab. 2 came out less than α, which makes it possible to reject H_0 and assume $\rho \neq 0$.

Table 1 Values of bulk density x_i [kg . m^{-3}] and corresponding tensile strength y_i [MPa]

i	x_i	y_i	i	x_i	y_i	i	x_i	y_i
1	23.53	0.316	11	33.82	0.378	21	44.41	0.449
2	27.94	0.223	12	33.47	0.405	22	43.65	0.476
3	28.23	0.276	13	35.58	0.391	23	43.12	0.452
4	33.52	0.212	14	40.88	0.374	24	36.76	0.449
5	32.64	0.288	15	47.65	0.473	25	41.47	0.394
6	36.47	0.232	16	36.06	0.428	26	40.29	0.396
7	33.20	0.308	17	37.65	0.415	27	40.85	0.405
8	35.88	0.309	18	44.52	0.511	28	42.06	0.441
9	36.90	0.309	19	44.12	0.500	29	41.99	0.449
10	31.17	0.318	20	39.70	0.469	30	40.35	0.408

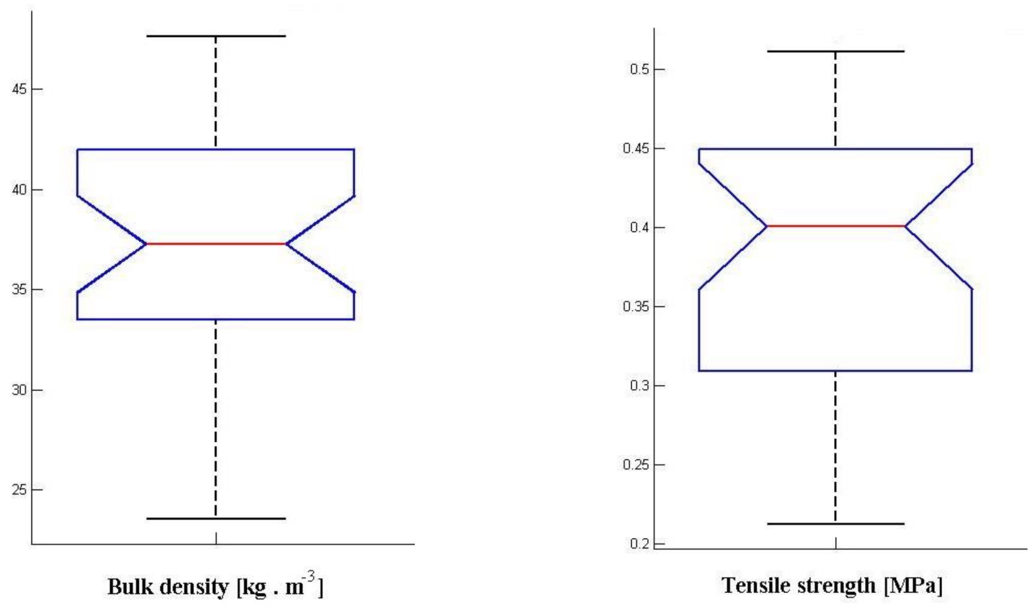

Figure 1 Boxplots of bulk density and tensile strength

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Table 2 Correlation coefficients calculated by different methods and their correlability at the significance level $\alpha = 0.05$

	Pearson	Spearman	Kendall
Correlation coefficient	0.7585	0.7996	0.6104
Correlability - p	1.194e-6	1.152e-7	2.648e-6

For regression analysis we have chosen 7 types of functions. The first six are polynomials up to the sixth degree and the seventh is an exponential function. Shapes of regression functions states (12)

$$\begin{aligned}
\text{Polynomial}\,1^{st}: &\quad y = a_1.x + a_0 \\
2^{nd}: &\quad y = a_2.x^2 + a_1.x + a_0 \\
3^{th}: &\quad y = a_3.x^3 + a_2.x^2 + a_1.x + a_0 \\
4^{th}: &\quad y = a_4.x^4 + a_3.x^3 + a_2.x^2 + a_1.x + a_0 \\
5^{th}: &\quad y = a_5.x^5 + a_4.x^4 + a_3.x^3 + a_2.x^2 + a_1.x + a_0 \\
6^{th}: &\quad y = a_6.x^6 + a_5.x^5 + a_4.x^4 + a_3.x^3 + a_2.x^2 + a_1.x + a_0 \\
\text{Exponential}: &\quad y = a_0.\exp(a_1.x)
\end{aligned} \tag{12}$$

In the Fig. 2, we plotted the measured values and fitted the first three polynomials and the exponential function. The polynomials 4^{th}, 5^{th} and 6^{th} order were not shown for clarity on the picture. However, there is an apparent tendency that the higher the degree of polynomial, the better it adapts to the measured values. Noteworthy is a 3^{rd} degree polynomial, in green, that curves down on the right side, which may indicate its poor ability to predict tensile strengths for higher bulk weights, as it is likely to go to zero values.

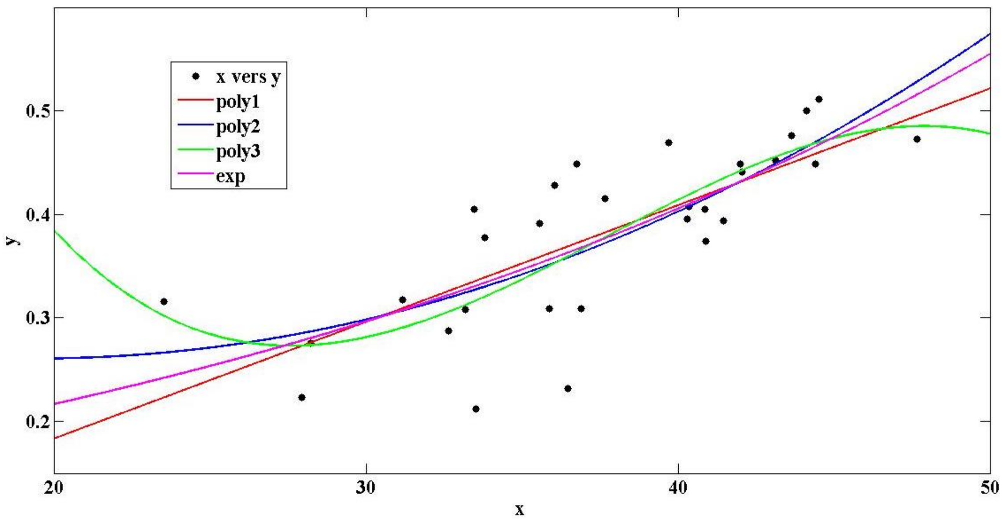

Figure 2 Different types of regression functions between bulk density x [kg·m^{-3}] and tensile strength y [MPa]

The characteristics of regression analysis were explained in the theoretical part and are presented for individual models in the Tab. 3. It can be seen that with increasing degree of polynomial the sum of squares for error (SSE) decreases, the exponential model fits between linear and quadratic function. The root mean squared error (RMSE) decreases only to the 3rd degree polynomial, then begins to grow. The coefficient of determination R^2 improves with increasing degree of polynomial, but its modified form R^{*2} improves the regression model only to the 3rd degree of the polynomial, then begins to decrease. The meaning of SSR and SST characteristics are explained above, DFE represents the number of degrees of freedom in the model. The test of significance of the regression model as a whole is done at the level $\alpha = 0.05$ and since p values are less than this value, we can conclude that the linear, quadratic, cubic and 4th degree models significantly contribute to the estimation of the dependent variable. We did the test only to the 4th degree polynomial, because at higher degrees numerical problems arose.

Table 3 Regression characteristics of different mathematical models, SST = 0.2039

Deg. pol.	SSE	RMSE	R^2	R^{*2}	SSR	p	DFE
1st	0.0866	0.0556	0.5753	0.5602	0.1173	1.19e-6	28
2nd	0.0817	0.0550	0.5994	0.5697	0.1222	4.33e-6	27
3rd	0.0762	0.0541	0.6261	0.5830	0.1277	9.43e-6	26
4th	0.0760	0.0551	0.6275	0.5679	0.1279	3.86e-5	25
5th	0.0729	0.0551	0.6423	0.5677	0.1310		24
6th	0.0727	0.0562	0.6434	0.5504	0.1312		23
exp.	0.0832	0.0545	0.5918	0.5773	0.1207		28

In the Tab. 4, we present point estimates of the coefficients in regression models. For polynomials, the index of the coefficient a_j also means its position at the degree of the independent variable x^j. Since these are only values calculated from our particular realization of random variables X, Y, it is also appropriate to make confidence intervals of the coefficients, which are given in the Tab. 5. However, except for the linear and exponential model, all intervals at the higher degrees of the polynomial intersect zero, thereby degrading the regression model.

Table 4 Point estimates of the coefficients in regression models

Deg. pol.	a_6	a_5	a_4	a_3	a_2	a_1	a_0
1st						1.127e-2	-4.184e-2
2nd					3.345e-4	-1.298e-2	0.3865
3rd				-5.081e-5	5.753e-3	-0.2014	2.519
4th			1.737e-6	3.002e-4	1.896e-2	-0.5064	5.105
5th		-1.04e-6	1.88e-4	-1.347e-2	0.4775	-8.371	58.2
6th	-6.645e-8	1.333e-5	-1.093e-3	4.679e-2	-1.098	13.34	-64.86
exp.						3.134e-2	0.1158

Table 5 Confidence intervals (95%) of the coefficients in regression models

Deg. pol.	a_6	a_5	a_4	a_3	a_2	a_1	a_0
1st from						7.521e-3	-0.1843
1st to						1.502e-2	0.1006
2nd from					-2.041e-4	-5.219e-2	-0.3176
2nd to					8.731e-4	2.624e-2	1.091
3rd from				-1.275e-4	-2.44e-3	-0.4884	-0.7725
3rd to				2.586e-5	1.395e-2	0.0856	5.81
4th from			-1.011e-5	-2.003e-3	-7.145e-2	-2.606	-12.85
4th to			1.358e-5	1.402e-3	0.1094	1.593	23.06
5th from		-3.195e-6	-1.981e-4	-4.079e-2	-0.4766	-24.8	-53.25
5th to		1.114e-6	5.741e-4	1.386e-2	1.432	8.055	169.6
6th from	-5.641e-7	-9.432e-5	-1.07e-2	-0.4054	-12.94	-150.1	-993.5
6th to	4.312e-7	1.21e-4	8.511e-3	0.4989	10.74	176.8	863.8
exp. from						2.088e-2	6.779e-2
exp. to						4.179e-2	0.1638

In the final Figures 3 - 6, we plot 95% confidence intervals of regression models by 1st, 2nd and 3rd degree polynomials as well as by the exponential model.

After reviewing all results, the linear and exponential forms of regression appear to be the best choices, while the exponential shows slightly more favorable values.

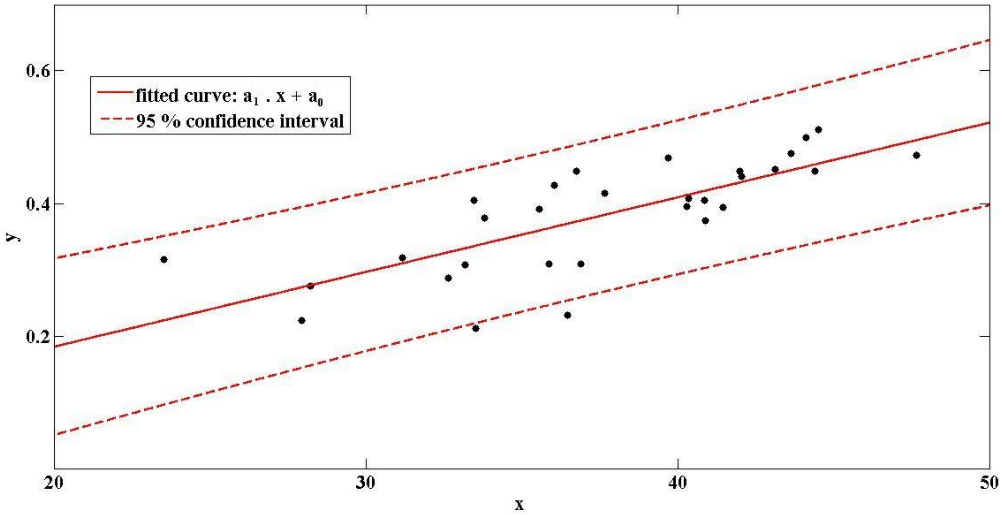

Figure 3 95% confidence interval for linear function: $y = a_1 \cdot x + a_0$

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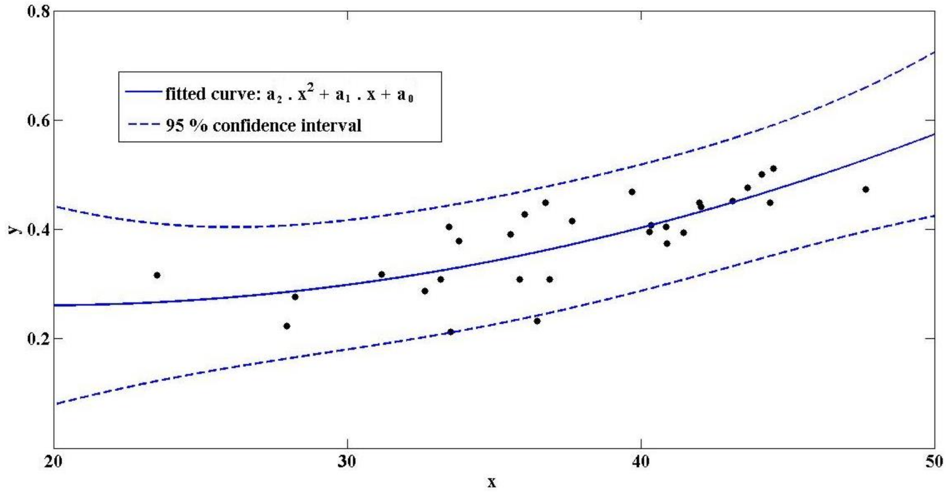

Figure 4 95% confidence interval for quadratic function: $y = a_2 \cdot x^2 + a_1 \cdot x + a_0$

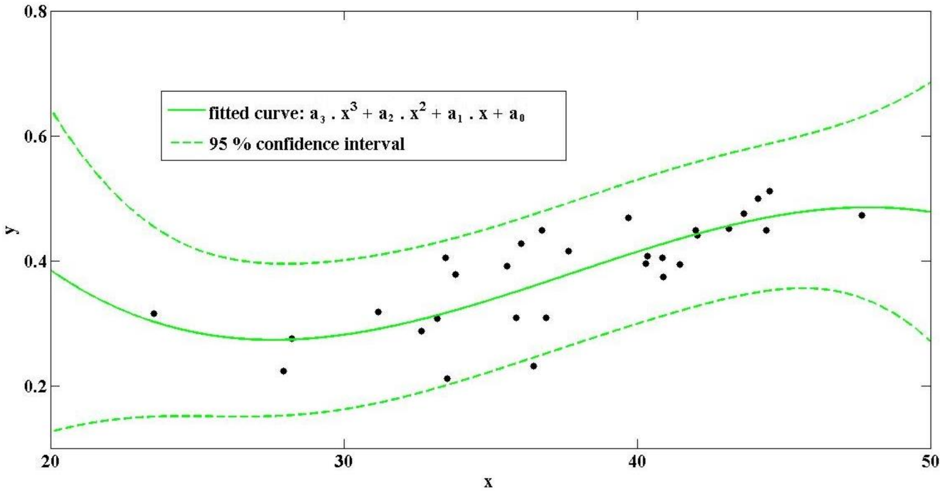

Figure 5 95% confidence interval for cubic function: $y = a_3 \cdot x^3 + a_2 \cdot x^2 + a_1 \cdot x + a_0$

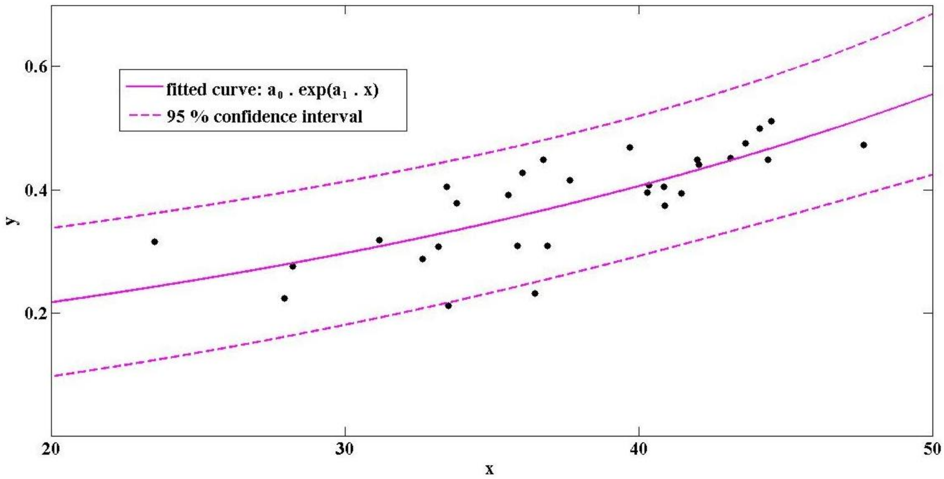

Figure 6 95% confidence interval for exponential function: $y = a_0 \cdot \exp(a_1 \cdot x)$

CONCLUSIONS

Expanded polystyrene (EPS) is a material that is concurrently environmental, practical and reliable [4]. Its use as a building material is miscellaneous and therefore deserves attention to determine its properties [3]. As EPS bulk density increases, tensile strength increases too [8]. It is important to as accurately as possible determine this functional dependence [11]. The intensity of the dependence is specified by various correlation coefficients, and their values in the range of about 0.6 - 0.8 indicate a relatively strong correlation found from the measured values [13]. The seven types of regression models used made it possible to calculate the characteristics of the corresponding model [12]. As we can see from the results, it is not necessary to complicate mathematical formulations of regression, it is sufficient to have a linear polynomial, which shows the best parameters and is also easier to calculate. Better came only exponential function, which also has a relatively uncomplicated formula.

REFERENCES

[1] Ching, J., Phoon, K.K., & Li, D.Q. (2016). Robust estimation of correlation coefficients among soil parameters under the multivariate normal framework. *Structural Safety*, 63, pp. 21-32, doi: https://doi.org/10.1016/j.strusafe.2016.07.002

[2] Chung, S. Y., Abd Elrahman, M., & Stephan, D. (2018). Effects of expanded polystyrene (EPS) sizes and arrangements on the properties of lightweight concrete. *Materials and Structures*, pp. 51-57, doi: https://doi.org/10.1617/s11527-018-1182-3

[3] Dafalla, M., Al Shuraim, M., & Shaker A. (2019). Influence of density and thickness on polystyrene insulated concrete block walls. *Int. J. of GEOMATE*, Vol. 17, No. 59, pp. 62-67, doi: https://doi.org/10.21660/2019.59.8108

[4] ISOVER Saint-Gobain, *EPS Expanded polystyrene – properties* (in Slovak). Retrieved 2020-01-29 from https://www.isover.sk/eps-expandovany-polystyren

[5] Novák, D., Teplý, B., & Shiraishi, N. (1993). Sensitivity analysis of structure: A review. *Civil Comp '93*, Edinburgh, Scotland, pp. 201-207.

[6] Ostertágová, E. (2015). *Applied statistics in the computer environment MATLAB*. Technical University Košice, 175 p. (in Slovak).

[7] Páleš, D., Lendelová, J., & Švec, O. (2000). Calculation of the rank correlation coefficients. *Workshop: Construmat 2000*, Slovak University of Agriculture, Nitra, pp. 148-152 (in Slovak).

[8] *POLYFORM Podolínec, Expanded polystyrene* (in Slovak). Retrieved 2020-01-29 from https://polyform.sk/wp-content/uploads/2016/04/eps.pdf

[9] Priecel, J. (1982). *Application of plastics for cover and roof constructions of agricultural buildings*. Candidate thesis, Slovak University of Agriculture in Nitra, Nitra, 143 p. (in Slovak).

[10] Priecel, J., & Páleš, D. (1998). Physical-mechanical properties of expanded polystyrene depending on the bulk density. *Workshop: Construmat '98*, University of Žilina, Súľov, pp. 191-195. (in Slovak).

[11] Sdružení EPS ČR, *Properties of expanded polystyrene (EPS)* (in Czech). Retrieved 2020-01-29 from https://stavba.tzb-info.cz/tepelne-izolace/8482-vlastnosti-expandovaneho-penoveho-polystyrenu-eps

[12] Sepah Vand, A., Sihag, P., Singh, B., & Zand, M. (2018). Comparative Evaluation of Infiltration Models. *KSCE Journal of Civil Engineering*, 22(10), pp. 4173-4184. doi: https://doi.org/10.1007/s12205-018-1347-1

[13] Vakharia, V., & Gujar, R. (2019). Prediction of compressive strength and Portland cement composition using cross-validation and feature ranking techniques. *Construction and Building Materials*, 225, pp. 292-301. doi: https://doi.org/10.1016/j.conbuildmat.2019.07.224

[14] Worden, K., Sohn, H., & Farrar, C.R. (2002). Novelty detection in a changing environment: Regression and interpolation approaches. *Journal of Sound and Vibration*, 258 (4), pp. 741-761. doi: https://doi.org/10.1006/jsvi.2002.5148

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Original Paper

The assessment of students' achievements from the subject Basics of Accounting in the study program Accounting at FEM SUA in Nitra

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ABSTRACT

The Faculty of Economics and Management is providing quality economic and managerial education within the accredited study programs. We analyzed the obtained students´ results of study program Accounting in the subject of Basics of Accounting. The analysis subject was the students' success in the before mentioned subject and changes in the final assessment. We assessed reached results of 318 students for 4 academic years, this subject was obligatory for these students. The final assessment was analyzed as a whole, as well as the manner these students achieved. We were interested whether the student met the conditions in an ordinary term. According to our opinion the analysis considered the necessary factor, the type of graduated secondary school. The average grade in individual terms was calculated by the arithmetic mean from all grades "A - FX", the total average grade was similarly calculated as the arithmetic mean of the final assessment recorded in the reports. In the analysis, the structure of students was also described through the mode, which is defined as the most common value of a statistical feature. We found out that the graduates of business academy prevail in the study program Accounting. We assumed that the graduates of business academies reach the best results in comparison with other students. However, the aggregated results of assessments did not confirm the existence of such an advantage. The worst average assessment is characteristic for the first corrective term, on the contrary, the best average grade is given in the second corrective term.

KEYWORDS: accounting, average grade, Basics of Accounting, education, teaching

JEL CLASSIFICATION: A 22, C 10, I 21, I 23

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INTRODUCTION

The modern society of the 21st century has brought with it the trend of learning society due to globalization. The system of education has been changing all over the world, this is caused by numerous social and political factors, situation in the labor market and technical progress [7]. The conditions of education, management of education process as well as motivation regarding new information options have been changed to new society requirements, globalization processes and value liberalization [10]. The working career of every person is conditioned by the level of education and acquired specialized competences [9]. The university teachers currently organize learning environments which involve their students through appropriate strategies and activities [5]. As noted by Horská et al. [3], universities search for possibilities to attract students, to offer them an education of a high quality and to bring value added and differentiation to the university education.

Current increasing competition of universities and a fight to obtain the interest of applicants for a study force schools to differentiate mainly by a quality and quality education. Not only the results but also the whole education process is significant at school and therefore it is indispensable to consider a quality as a main feature of our universities [14]. According to [11] in general a term education quality is a required (optimal) level of function and production which might be set by certain requirements (e.g. education standards). Based on them it can be objectively measured and assessed. The quality education is a condition for the securing of permanent innovations in education [15].

Universities and colleges enroll students from different types of secondary schools and therefore their level of secondary school knowledge is different [2]. Accounting is a subject educated not only at business academies where the scope education is the largest but as well as at other secondary schools, e.g. hotel academies, business schools, agricultural secondary schools, secondary vocational schools and others. Except for secondary schools several universities and high schools with an economic focus educate the accounting [13]. Accounting education at secondary school is simple as regards its substance and connection to practice. A teacher cannot be limited to the use of the same education methods in different classes or groups during the accounting education. Education methods should be adequately chosen, changed, alternated and combined. Modern activating methods of education significantly influence the education results and are attractive for students [4].

In recent years the content and scope of education has been changed, the criteria for admitting students to secondary or high schools have been constantly changing, and therefore, in connection with these changes, it is necessary to innovate also the forms of education and methods of assessment. The adaptation phase of students to a high school study is limited by the student’s entry to a high school and the end of second – third semester. A beginner at a high school needs to adapt to increasing requirements for independent and responsible action, changed (usually increased) demand for a study [1], [12].

Current trends in education include the application of e-learning methods that are used in online teaching, provide support in self-study and also enable the assessment of students' knowledge. In the individual study, it is possible to use tools for the evaluation of tasks and assignments, which students elaborate at home, and the obtained point evaluation is a part of the final grade on the exam [8]. Feedback is an important part of an educational process because the analysis of the study outcomes enables teachers to evaluate its quality [6].

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MATERIAL AND METHODS

The Faculty of Economics and Management is providing quality economic and managerial education within the accredited study programs in all three study levels. The Bachelor study provides the study program Accounting. This study program is the most coveted study program focused on the acquiring the skills in the bookkeeping of business entities, preparing and analysis of financial statements also by means of computer-assisted techniques, the area of cost accounting, taxes of natural persons and other subjects.

In connection to upcoming accreditation of high schools and universities, we analyzed the obtained students´ results of study program Accounting in the subject of Basics of Accounting. The students´ success in the before mentioned subject and changes in the final assessment was the subject of the analysis. We assessed reached results of 318 students for 4 academic years, this subject was obligatory for these students. The final assessment was analyzed as a whole, as well as the manner these students achieved. We were interested whether the student met the conditions in an ordinary term. According to our opinion the analysis considered the necessary factor, the type of graduated secondary school. Descriptive characteristics were utilized in order to describe the analyzed phenomena.

The average grade in individual terms was calculated by the arithmetic mean from all grades “A-FX”, the total average grade was similarly calculated as the arithmetic mean of the final assessment recorded in the reports.

$$\bar{x} = \frac{\sum_{i=1}^{k} x_i n_i}{\sum_{i=1}^{k} n_i}$$

In the analysis, the structure of students was also described through the mode, which is defined as the most common value of a statistical feature.

RESULTS AND DISCUSSION

The accounting information system is the part of company information system. The basic of all accounting is presented by the valid legal norms which must be understood and applied in practice. The education subject Basics of Accounting belongs to more challenging economic subjects. It requires to understand the theory, practice and to know the mutual relations, to follow the legislative amendments and to apply the knowledge in practice.

Initially, accounting was combined with mathematics. According to an English proverb: If the result does not depend on the method of solution, it is mathematics, if it depends, it is accounting. The connection of accounting and mathematics presented the enemy for most students, the electronic bookkeeping breaks this barrier for them. Despite of this the accounting is the subject which is challenging for students for several reasons. The accounting is combined with the economic environment in which the students are not able to orientate as it links several professional economic concepts. They have not yet been adapted by them, the accounting is mapping the processes which are relatively abstract and follow several principles which must be understood and applied by the students.

The knowledge and skills which students obtain during the study in this subject very closely connect to the whole group of other subjects. During its education it is indispensable to respect the mutual intrasubject relations. The subject leads the students to acquire the

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theoretical knowledge and skills in the double entry bookkeeping, to handle the methodology, accounting procedures and double entry bookkeeping and to be able to analyze the financial situation of accounting entities based on the data from accounting.

The methods, forms and means of accounting education must simulate the development of students' cognitive abilities, to support their purposefulness, autonomy and creativity. The form of interpretation, controlled conversation, problem teaching is used during the education. We prefer the work with textbooks, workbooks and means of computing. The students are motivated by the examples from practice. Different accounting professional magazines are recommended. In our opinion it is indispensable to stimulate the students' cognitive abilities, to apply the proportional representation and linking of practical and theoretical knowledge.

The study program Accounting belongs to the most attractive study program in FEM since its inception. Currently as regards the ongoing demographic process, the slight decrease in the students' number was recorded in comparison with the prior periods (Table 1).

Table 1 Students' structure according to years and graduated secondary school

	Type of graduated secondary school				
School year	Grammar school	Hotel academy	Business academy	Other sec. school	Total
2016/17	7	2	68	12	89
2017/18	10	10	44	10	74
2018/19	8	5	46	17	76
2019/20	8	8	48	15	79
Total	33	25	206	52	318

This study program is dominated by students – graduates of business academies, who make up almost two thirds of students (64.78%) studying in this study program. Currently the graduates of grammar school present in average 10.51% (7.87% - 13.51%) students' portion in the study program Accounting (Figure 1).

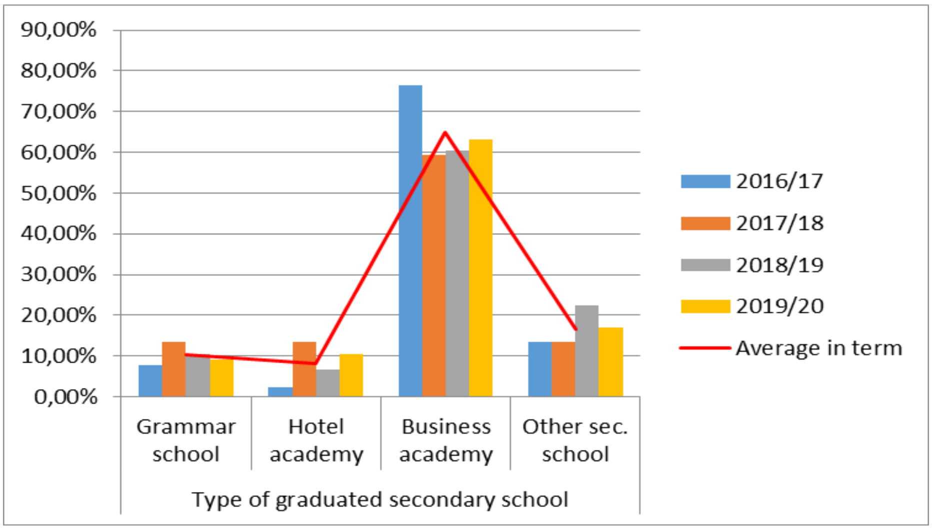

Figure 1 Students' structure according to years and graduated secondary school

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It was stated in the methodology that the final assessments were at disposal, i.e. the grades from students' exams which served as the research base. In fact, data were available for only 285 respondents, as 33 students who graduated the subject did not take the exam at any term. Students who did not take the exam were presented by the graduates of business academy (Figure 2), who formed more than the half of these students (17.52%).

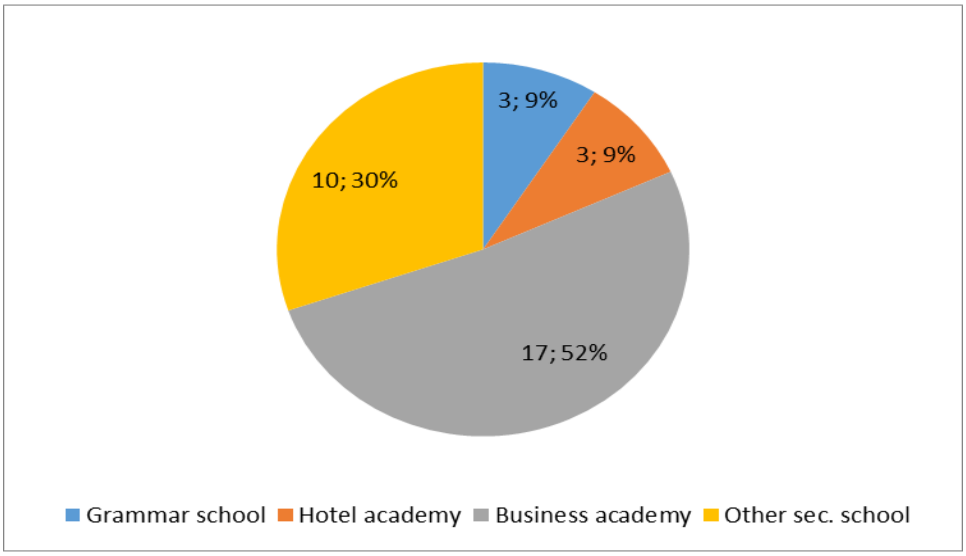

Figure 2 Students' structure who did not take the exam, according to the type of graduated secondary school

Students who took at least one exam term (285) presented the number 189 students (64.78%) who graduated business academy, i.e. these students were already aware of theoretical as well as practical side and the subject Basics of Accounting graduated at FEM should confirm their knowledge. The type of graduated secondary school should be a comparative advantage for them in comparison with the students from other types of secondary schools, mainly grammar school. The aggregated results of assessment did not confirm the existence of such an advantage (Table 2; Figure 3). The best average grade was achieved by the students of hotel academy. Graduates of secondary vocational schools and business academies performed approximately "equally" well. The worst average grade was obtained by grammar school graduates, but its value differs only slightly from the others.

Table 2 Average assessment of students according to term and graduated secondary school

	Type of graduated secondary school				
Exam term	Grammar school	Hotel academy	Business academy	Other sec. school	Average in term
ordinary	3.155	2.639	3.042	3.275	3.062
1st corrective	3.000	2.750	3.177	3.018	3.105
2nd corrective	2.750	2.500	2.870	3.000	2.867
total	2.823	2.660	2.765	2.755	2.761

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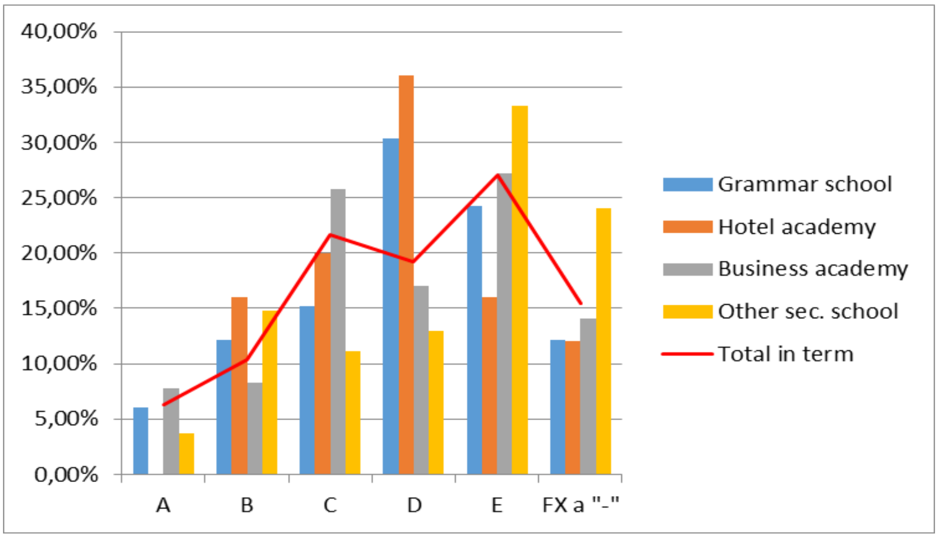

Figure 3 Students' structure according to graduated secondary school and total assessment (regardless the term)

If we assess the success of students in the exam from the subject Basics of Accounting, it is necessary to consider also a term in which students performed the exam. Table 2 presents that the worst average assessment is characterized for the 1st corrective term, vice versa the best one was granted in the 2nd corrective term.

Almost 53.38% of all students do not meet the exam conditions in an ordinary term and therefore they obtain the grade "FX" (Table 3). Insufficient knowledge occurs most frequently in an ordinary term among graduates of other secondary schools (65.00%) vice versa the students of hotel academy have the best success in an ordinary term even none of them obtained the grade "A". The assessment "insufficient" is given only to 27.78% of tested students.

Table 3 Portion of achieved final students' assessment in an ordinary term

	Type of graduated secondary school				
Assessment	Grammar school	Hotel academy	Business academy	Other sec. school	Total in term
A	3.448%	0.000%	7.263%	2.500%	5.639%
B	6.897%	22.222%	7.821%	15.000%	9.774%
C	17.241%	16.667%	18.994%	7.500%	16.917%
D	10.345%	27.778%	7.263%	5.000%	8.647%
E	6.897%	5.556%	5.587%	5.000%	5.639%
FX	55.172%	27.778%	53.073%	65.000%	53.383%
Total	100.000%	100.000%	100.000%	100.000%	100.000%

CONCLUSIONS

The task of educated subject Basics of Accounting is to provide students with knowledge, skills and competences in the area of double entry bookkeeping. Students should be able to manage the methodology and accounting procedures, to absorb the theoretical knowledge, to form the logical thinking and to develop skills and key competences utilized also in further education, within practice and civilian life.

We found out that the graduates of business academy prevail in the study program Accounting, they form almost two thirds of students (64.78%). The final assessments i.e. exam grades of 318 students were at disposal. The surprising finding was that the 33 students who passed the course did not take the exam at any time. More than the half of them was presented by the graduates of business academies (17.52%). We assumed that the graduates of business academies reach the best results in comparison with other students, mainly of grammar school. However, the aggregated results of assessments did not confirm the existence of such an advantage. The best average grade was obtained by the graduates of hotel academy. It is also interesting to note that up to 53.38% of all students do not pass the conditions of the exam in due time. The worst average assessment is characteristic for the 1st corrective term, on the contrary, the best average grade is given in the 2nd corrective term. And students of hotel academies have the best success in an ordinary term, even though none of them received an "A".

REFERENCES

[1] Čeryová, D., Kapustová, Z. & Poláček, M. (2020). Adaptation of students to university studies. *Selected questions of tertiary education at the Slovak University of Agriculture in Nitra*. 1st edition. online (664 p.). pp. 107-125 (in Slovak).

[2] Hornyák Gregáňová, R. (2017). Financial and insurance mathematics in the context of economic and managerial university education. *ICERI 2017 - proceedings from conference ICERI 2017*. Valencia: IATED, pp. 7450-7455.

[3] Horská, E., Ubrežiová, I. & Palková, Z. (2015). *Quality and value related aspects of the higher education: a case of the Slovak University of Agriculture in Nitra*. Development of Public Accreditation of Agricultural programs in Russia (PACAgro) (543902-TEMPUS-1-2013-1-SK-TEMPUS-SMGR). Retrieved 2019-10-10 from http://spbgau.ru/files/nid/3515/sbornik_tempus_2015.pdf

[4] Loduhová, A., Kadlicová, D. & Jakubeková, M. (2014). *Modern teaching of accounting*. Bratislava: MPC. 72 p. (in Slovak).

[5] Lozano-Oyola, M. (2016). A study of the improvement of academic performance in new entry students via teaching and evaluation innovations. *ICERI 2016 Proceedings*, pp. 1142-1151, Seville/Spain: IATED.

[6] Matušek, V. & Hornyák Gregáňová, R. (2019). Comparison of exam results in Mathematics at Faculty of Economics and Management, Slovak University of Agriculture in Nitra. *Mathematics in education, research and applications* online, vol. 5, no. 2, pp. 78-83. doi: https://doi.org/10.15414/meraa.2019.05.02.78-83

[7] Novikov, F. & Novikova, M. (2019). Specifics of international postgraduate students' education (based on the experience of teaching linguistics in Rudn). *INTED 2019 - proceedings from conference INTED 2019.* Valencia: IATED, pp. 2761-2766.

[8] Országhová, D. (2019). Future managers knowledge and competences in the context of university mathematics education. *Modern technologies in education*. Opole: Wyższa Szkoła Zarządzania i Administracji w Opolu, pp. 84-105. Retrieved 2020-09-18 from http://pedagogika.wszia.opole.pl/ebook/mono2019_2.pdf

[9] Országhová, D. (2020) Study results comparison in Mathematics with English language of instruction. *Mathematics in education, research and applications* online, vol. 6, no. 1, pp. 40-46. Doi: https://doi.org/10.15414/meraa.2020.06.01.40-46

[10] Petlák, E. (2019). *Motivation in the educational process*. Bratislava: Wolters Kluver. 104 p. (in Slovak).

[11] Průcha, J. & Veteška, J. (2014). *Andragogical dictionary 2*. Grada Publishing a.s. 320 p. (in Czech).

[12] Šeben Zaťková, T. (2014). *Introduction into the university pedagogy*. Trnava: Univerzita sv. Cyrila a Metoda v Trnave. 1st edition. 206 p. (in Slovak).

[13] Šlosár, R. (2008). *History of accounting in Slovakia*. Bratislava: Wolters Kluver. 234 p. (in Slovak).

[14] Švikruhová, P., Šeben Zaťková, T. & Kapsdorferova, Z. (2020). Evaluation of quality of the subject Quality management. *Selected questions of tertiary education at the Slovak University of Agriculture in Nitra*. 1st edition. online (664 p.). pp. 554-576 (in Slovak).

[15] Turek, I. (2009). *Quality of education*. Iura Edition (in Slovak).

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Original Paper

Consumers' motivation and purchasing behavior in selected shopping chain with grocery: a case study

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ABSTRACT

Food products are among the most frequently purchased goods, because they are part of the basic life necessities of every individual. In this paper, we focused on the shopping behavior of consumers who buy products in the shopping chain COOP Jednota. The main goal was the analysis of motivational and purchasing behavior of consumers and statistical evaluation of independence between observed features. We obtained data for the analysis by the method of questionnaire and we evaluated the answers of the respondents focused on four research questions. We applied χ^2- test of independence to determine dependence between these statistical features: respondent's education, frequency of respondent's purchases, effect of advertising on purchasing of consumers, and amount of the monthly payment for the purchase. Results confirmed that there is dependence between the respondent's education and the frequency of purchases in the mentioned shopping chain. The dependence was not approved in the following three cases: between the respondent's education and the incentive effect of advertising on purchases; between the respondent's education and the monthly payment for the purchase, and between the frequency of purchases in the COOP Jednota chain and the motivational effect of advertising on the respondent's purchase.

KEYWORDS: questionnaire survey, purchasing behavior, COOP Jednota shopping chain, χ^2- test of independence

JEL CLASSIFICATION: M20, C12

INTRODUCTION

The four main marketing tools, product, price, place, and promotion, have become the basis of the marketing theory in examining consumer behavior and preferences when purchasing products and services. Retailers need to consider very carefully what goods and to whom they will offer, what pricing policy they will use when selling a product, where and how they will

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sell, and how they will motivate and attract consumers' interest in shopping using various types of promotion.

The food industry covers a wide area from the processing of agricultural products to the production of food products, which are then offered to consumers in the required quantity, range and quality. Food production and consumption is under constant control in order to properly assess the economic, financial, health and potential environmental consequences for the life of society [6].

As stated by Korauš [4], price is an important tool of the marketing mix, which as a direct tool brings the company a profit. For the consumer, the price is an important factor in the purchase and expresses how much the consumer is able or willing to pay for a certain tangible or intangible goods.

New trends in purchasing behavior include event marketing, which creates or mediates new experience for the buyer. Experience create different emotions in people, which influence their shopping behavior and can contribute to a positive perception of the product brand, but also of the company as a whole [9].

As Kunová [5] points out, during the purchase of food products, consumers observe various factories, and on this basis the following three groups can be characterized. The first group of consumers mainly monitors food prices and buys products during time of special offers. The second group includes consumers who buy delicacies of all kinds and do not look at their price and the amount of nutrients they contain. The third group of consumers concentrates on the nutritional and health factors of purchased food or require organic food.

The interest in buying organic food is associated with the health problems of consumers or with the trends of healthy lifestyle [13]. Consumers are interested in the special effects of substances that are contained in fruits and vegetables on human health [1]. The young generation of consumers forms their own habits of consuming and buying food and sellers must respond to them [10].

In this contribution, we focused on the shopping behavior of consumers who buy food in the COOP Jednota shopping chain. This sales network offers customers the opportunity to purchase daily necessities in one place and, in addition to food, also offers selected products from the drugstore and household goods. We know from the history of the company that it belongs to the oldest trading systems in the Slovak Republic. This company was founded in 1845 by Samuel Jurkovič as the first cooperative in Slovakia and was called the Farm Association. Later, in 1869, Samuel Ormis founded the first Food Association in Revúca, which was the predecessor of cooperative retail. Since then, the company has been continuously managed, has undergone many changes and continues to this day [11].

MATERIAL AND METHODS

The main source of material for the paper was a questionnaire survey among respondents from Slovakia. The questionnaire survey was conducted in 2019 and was focused on consumers who buy in the shopping chain named COOP Jednota Slovensko. 220 respondents were contacted, either through online questionnaire on the Internet or in the printed form. The questionnaire contained 21 questions, of which 3 questions were identification questions.

Together, we analyzed the answers of respondents from 172 questionnaires. The answers show that 40% of respondents came from eastern Slovakia, 36% of respondents were from western Slovakia and 24% of respondents were from central Slovakia. We excluded respondents who do not buy in this shopping chain from further analyzes.

The obtained data from the questionnaire were sorted out and formulated hypotheses were verified by χ^2- test of independence. This method is often used to evaluate data of conducted questionnaires and to determine the independence (or dependence) of selected features, based on a contingency table of examined characters.

The test statistics is given by

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{s}\frac{(n_{ij} - n'_{ij})^2}{n'_{ij}}$$

where n_{ij} indicates experimental frequencies, n'_{ij} indicates expected frequencies. We reject the null hypothesis at the chosen level of significance α if the value of the test criterion exceeds the tabular critical value for the corresponding number of degrees of freedom $k = (r - 1)(s - 1)$.

The formula of the contingency coefficient is

$$C = \sqrt{\frac{\chi^2}{n + \chi^2}}$$

where n is the number of elements in the research sample [3], [8].

In our research we verified the following research questions, assuming a customer's purchase in the COOP Jednota chain:

Is there a relationship between selected statistical features?
1. Between respondent's education and the frequency of purchases?
2. Between respondent's education and the motivational effect of advertising on purchasing?
3. Between respondent's education and the amount of the monthly payment for the purchase?
4. Between the frequency of purchases and the motivational effect of advertising on the respondent's purchase?

The test results were processed using MS Excel tools.

RESULTS

The first classification question was about the sex of the respondents and the results are graphically shown in Fig. 1. We see that women predominate in the research sample, which corresponds to the real situation that food purchases for the family are provided mainly by women and they have an overview of what food products and meals the family consumes almost every day.

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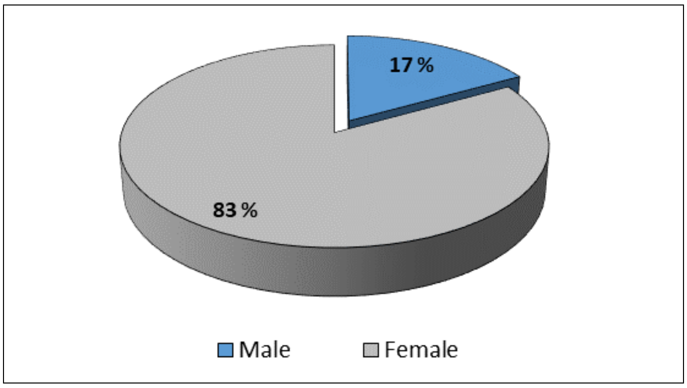

Figure 1 Distribution of respondents by sex
Source: authors

In the second question, we obtained an overview of the respondents' education. The results show that in the research sample respondents with a university degree dominate (Fig. 2). This is also due to the fact that respondents who have experience with the usage of various digital tools answered the questionnaire via the Internet.

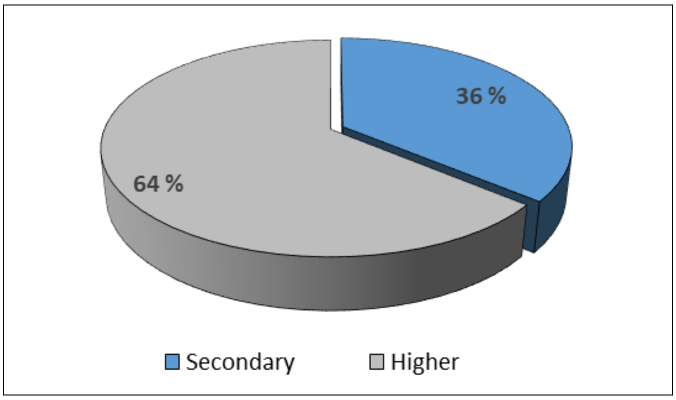

Figure 2 Distribution of respondents by education level
Source: authors

In the questionnaire the respondents were asked to answer how often they shop in the COOP Jednota shopping chain. The analysis of answers in absolute terms is presented in Fig. 3. We can see that out of the research sample, most respondents shop daily (64.5%) in the mentioned supply chain.

A strategic location in the territory of Slovakia is important for a well-functioning and stable company. The company COOP Jednota has almost 2,200 shops and operations, which are located in cities, housing estates, but mainly in the countryside, where these shops are sometimes the only source where food and non-food goods can be bought. The COOP Jednota shopping chain offers customers interested in a healthy lifestyle a product line under the "BIO" and "Active Life" brands [10].

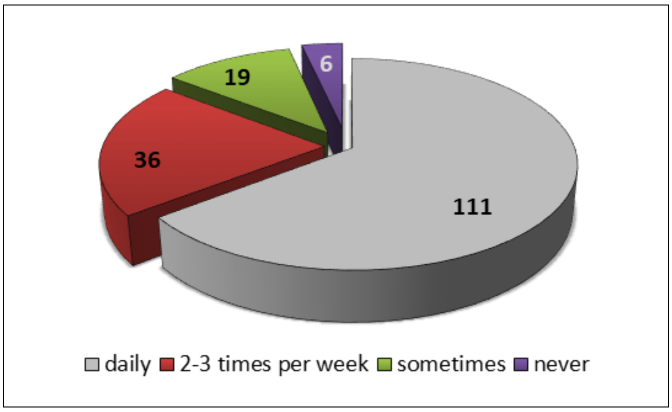

Figure 3 Frequency of respondents purchases in COOP Jednota
Source: authors

Advertising is an important factor in gaining customers and effective way of purchase motivation. In the following question, respondents had to indicate whether their purchase was motivated by advertising. Advertising of the company COOP Jednota is actively broadcast on television, is humorous and appeals to consumers at the national level. From the presented analysis of the answers (Fig. 4) we see that 71 respondents (41.3%) declared a positive answer, which means that they were motivated by advertising to do a purchase. The product range is focused on Slovak manufacturers, which means that the COOP Jednota chain gains customers who return for shopping and buy preferred types of products and goods.

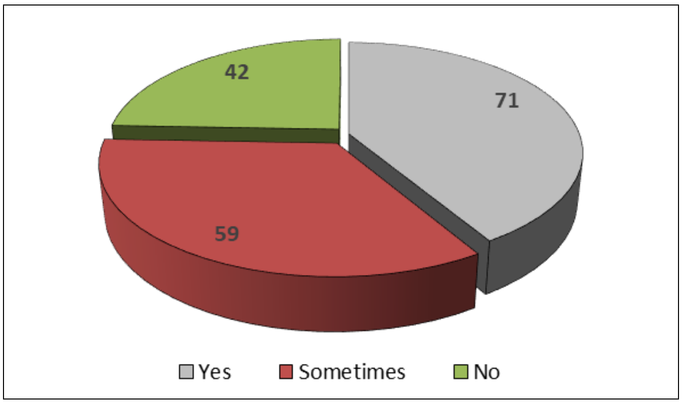

Figure 4 Advertising as a motivational factor of purchase
Source: authors

All retailers want to motivate consumers' shopping activity by different means and ways. Next important motivating means for the purchase of consumers are stock prices and discounts, which subsequently affect the amount of the monthly payment.

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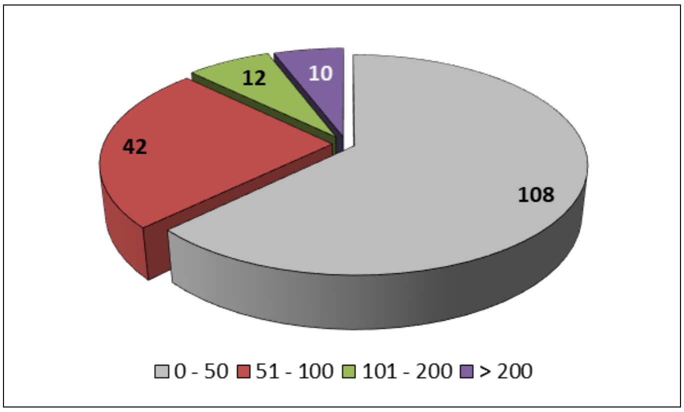

Figure 5 Distribution of respondents by the amount of payment per month in COOP Jednota
Source: authors

The answers of the respondents to the question about the amount of payment per month in COOP Jednota are processed in Fig. 5. From the results follows that the respondents who pay monthly up to 50 euros in COOP Jednota (108 participants; 62.8%) have a clear predominance.

In the following section we present results of the dependency testing via χ^2 - test between these characters: Respondent's education, Frequency of purchases, Payment amount per month, and Motivation by advertising. We test the null hypothesis: the characters *X* and *Y* are independent, in the contrary to the alternative hypothesis: the characters *X* and *Y* are dependent. The results of hypotheses testing are summarized in Tab. 1.

Table 1 Results of χ^2- test of independence, significance level α = 0.05

	Feature *X*	Feature *Y*	Test statistics	Critical value	Contingency coefficient
1	Respondent's education	Frequency of purchases	53.78*	12.59	0.49
2	Respondent's education	Motivation by advertising	9.02	9.49	-
3	Respondent's education	Payment per month	4.63	12.59	-
4	Frequency of purchases	Motivation by advertising	9.69	12.59	-

Source: authors

Based on the χ^2 - test of independence, we can make following conclusions:

In the first case, the existence of statistically significant dependence between the respondent's education and the frequency of purchases in the COOP Jednota chain was confirmed. Using the contingency coefficient, the strength of this dependence was determined as a moderate. In the second case, the dependence between respondent's education and the motivation for shopping by advertising was not confirmed. In the third case, the dependence between the respondent's education and the amount of payment per month in the COOP Jednota chain was not approved. In the fourth case, there was not confirmed the dependence between the frequency of purchases in the COOP Jednota chain and the motivational effect of advertising on the respondent's purchase.

Presented results are an analysis of the shopping behavior of a part of the Slovak customers in 2019. A phenomenon of digitalization has impact on the life of the whole society and changes the character of practical routines of people. What are the shopping prospects in terms of the special situation during the spread of coronavirus in year 2020?

Digital tools support online shopping that is one of contemporary trends and creates new competitive advantages in the field of sale. Online shopping habits of consumers are the objective of research studies, e.g. finding the correlation between food-related lifestyle of consumers and online specialty food-buying behavior, and results help managers improve their marketing strategies on the website [12]. Laguna with co-authors [7] presented results of the surveys about food priorities during lockdown caused by coronavirus and found out that customers reduced the frequency of shopping, but no changes had occurred at the place of purchase. Knowing consumer behavior in different countries and regions helps marketing professionals to develop new business strategies for global markets; it would be appropriate to develop models that comprehensively express consumer behavior in different regions [2].

CONCLUSIONS

Buying food is one of the activities that consumers do almost every day, and this process is influenced by various factors. In the paper we presented a part of results of a questionnaire survey, which was focused on the preferences of consumers who buy food products in the COOP Jednota shopping chain. In the research sample there was the predominance of women. In the context of education, 64% of respondents were with the higher education and 36% with the secondary education. As the main objective we investigated the existence of statistical dependence between pairs of chosen features. The statistical dependence between the respondent's education and the frequency of purchases was confirmed by χ^2- test of independence. In three cases we obtained the same conclusion: there is not dependence between the respondent's education and the motivational impact of purchase advertising; there is not dependence between the respondent's education and the amount of payment per month in the COOP Jednota chain; and finally, there is not dependence between the frequency of purchases and the motivation of the purchase by advertising. Knowing the opinions of consumers is the important prerequisite for correct decisions of the company and the advantage in choosing a marketing strategy for product sales.

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REFERENCES

[1] Durec, J., Kozelová, D., Matejková, E., Fikselová, M., & Jakabová, S. (2019). Fruit as a source of antioxidants and trends in its consumption. *Potravinárstvo Slovak Journal of Food Sciences*, 13, 1 (2019), pp. 251-257. doi: https://doi.org/10.5219/1042

[2] Hamed, S., & El-Deeb, S. (2020). Cash on Delivery as a Determinant of E-Commerce Growth in Emerging Markets. *Journal of Global Marketing*, 1-24.

[3] Chajdiak, J. (2013). *Analysis of questionnaire data.* STATIS: Bratislava. 108 p. (in Slovak).

[4] Korauš, A. (2011). *Financial marketing.* Bratislava: Sprint dva (in Slovak).

[5] Kunová, V. (2011). *Healthy nutrition - 2*. Grada (in Czech).

[6] Lacková, A., & Karkaliková, M. (2010). *Commodity knowledge of foodstuffs*. EKONÓM (in Slovak).

[7] Laguna, L., Fiszman, S., Puerta, P., Chaya, C., & Tárrega, A. (2020). The impact of COVID-19 lockdown on food priorities. Results from a preliminary study using social media and an online survey with Spanish consumers. *Food Quality and Preference*, 86, 104028.

[8] Markechová, D., Tirpáková, A., & Stehlíková, B. (2011). *Basis of Statistics for Teachers*. The Constantine Philosopher University in Nitra, Edition Prírodovedec, no. 458, 405 p. (in Slovak).

[9] Nagyová, Ľ. et al. (2014). *Marketing*. Nitra: Slovak University of Agriculture in Nitra (in Slovak).

[10] Országhová, D., & Fľak, P. (2019). Biofood in nourishment of university students (case study). *University mathematics education as basis for innovations in science and technics*, pp. 42-50. Retrieved 2020-09-29 from http://www.slpk/eldo/2019/zborniky/9788055220284/orszaghova-flak.pdf

[11] Petreková, G. (2019). *Marketing mix in the company COOP Jednota*. Slovak University of Agriculture in Nitra. Diploma thesis (in Slovak).

[12] Rong-Da Liang, A., & Lim, W. M. (2011). Exploring the online buying behavior of specialty food shoppers. *International Journal of Hospitality Management*, 30(4), 855-865. doi: https://doi.org/10.1016/j.ijhm.2011.01.006

[13] Ubrežiová, I., Kráľová, T., & Kozáková, J. (2019). Factors influencing interest of Slovak consumers' in organic dairy products. *Potravinárstvo Slovak Journal of Food Sciences*. 13,1 (2019), pp. 538-546. doi: https://doi.org/10.5219/1137

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Original Paper

Analysis and evaluation of students' results in the subject of Mathematics for Technicians

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ABSTRACT

Integral calculus is a branch of mathematics concerned with the determination, properties, and application of integrals. It is predominantly used in technical applications. Technical engineers, statics, physicists and others use it in their calculations on practice. There was a requirement from practice for technical universities to include integral calculus in their curricula. The subject Mathematics for Technicians is taught at the Department of Mathematics, the Slovak University of Agriculture in Nitra. The content of this subject is to teach its students to calculate indefinite and definite integral. Our research analysed students' knowledge in counting indefinite and definite integral. We used the methodology of evaluation and comparison of test results taken in the 8th week of the term and at the end of the term. The main hypothesis saying that the results of students' tests taken at the end of the term are better that those taken in the mid- term has confirmed to be correct.

KEYWORDS: integral calculus, definite and indefinite integral, tests, requirements from practice, mathematical statistics

JEL CLASSIFICATION: C02, C11, I210

INTRODUCTION

At present, the role of mathematics has increased significantly. Various areas of mathematics, including integral calculus are applied in different fields of technology and economics. By penetrating mathematics into technology and economics, a certain increase of knowledge of economic phenomena and processes might be achieved. For better mastering technical and economic theories, our mathematical experience and knowledge should be used. One way of motivating students is to point out the need to master mathematics and its subsequent

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introduction in different applications. This will simplify and solve many situations and problems in various areas of application of mathematics. According to Hornyák Gregáňová and Országhová [3], specialized economic positions require educated and skilled graduates. Our Slovak universities with economic bias offer their students a lot of opportunities to broaden their knowledge in the areas directly connected with those requirements of practice. Ferenczi Vaňová, Hornyák Gregáňová, Váryová and Košovská [2] say that "The essential condition for learning is the motivation that affects the results of learning in different situations. Motivation determines intrinsic activation of students resulting from their needs and is relevant to their claims. Motives present the intrinsic motives or incentives, activities designed to achieve a specific objective. They can be considered as the reasons for student's behaviour. For each individual there are many different motives that are interrelated and constitute a form of hierarchy." An analysis done by Országhová, Fľak and Papcunová [6] pointed to a declining number of students in external and internal forms of study at Slovak universities. We anticipate various causes of this decline. One of them is demographic changes in the country; the other is the preference of Slovak students to study at universities abroad or a small opportunity to find an adequate job in the field of study. Országhová [5] says that a key factor in the functioning of the information society is education, whose aim is to ensure that people are able to find and understand the information, then apply it correctly.

Teaching experience says that students continue to have problems with methods of integration. Using the most efficient method saves a lot of work and frustration. One of the basic techniques used in mathematics is, according to Kecskés [4], a differentiation and integration/anti-differentiation. These operations are inverse to each other. "While differentiation (to the extent of school mathematics) is relatively simple and straightforward, integration, in general, is a much more involving task. There are various classical methods to evaluate elementary integrals, e.g. substitution, integration by parts, partial fraction decomposition or more advanced techniques like the residue theorem, or Cauchy's integral formula." [4].

Dawson [1] also encourages students to find and think about patterns in integrals, and to see connections between different parts of the undergraduate mathematical curriculum. Some students continued to prefer integration by parts; others quickly came to prefer the method of undetermined coefficients.

MATERIAL AND METHODS

Integral calculus is a part of the teaching syllabus at the Faculty of Engineering, SUA in Nitra. In order to be able to correctly calculate indefinite and definite integrals, we need to know the basics of functions.

In the teaching mathematics at our university we use three integration techniques. Integral formulas can be considered as the reverse process of differentiation - it is called the Inverse Differentiation. Integration is the process of finding a function with its derivative. When we speak about integration by parts, it is done with regard to integrating the product of two functions.

When integrating functions, we try to put them into the form of simple elementary functions, which we can solve either directly or using various methods (per partes - integration by parts, or a substitution). Unlike derivatives, integration is much more difficult as there are no rules for integrating a product, fraction, or complex function. In addition, the rule is that if there is one to the primitive function, there are infinitely many of them and they differ by a constant.

One of the basic integration techniques used in calculating integrals is the decomposition method and the use of formulas. We try to divide the given function into several integrals so that each integral can then be calculated by using formulas. Another method is substitution, where we replace the integrated function (part of the integrated function) with a new variable. In substitution, it is important for the derivation of the function (substitution) to be part of an internal function in the integral. Another integration technique to consider in evaluating indefinite integrals that do not fit the basic formulas, is integration by parts. The per partes integration method is used to integrate the product of functions. We do not always use per partes methods when integrating a product. The aim is to correctly understand definitions and sentences, learn to integrate different types of functions so they can be applied into real life problems.

Learning to integrate functions also means studying definitions and sentences, learning to integrate different types of functions, being able to use them in other mathematical parts (eg double integral) as well as in solving mathematical or technical real-life situations.

The aim of the paper is to determine the level of knowledge of students in the field of integral calculus. In the research participated students of the Technical Faculty of the Slovak University of Agriculture in Nitra.

We have set the following research goals:
• find out the level of students' knowledge in the field of integral calculus,
• compare the level of functional thinking in two different groups of students in the subject of Mathematics for Technicians lectured at the Faculty of Engineering of the university - students were tested in the 8th week of the term and at the end of the term,
• analyze the frequency of errors in individual tasks and draw attention to the most common ones.

We used theoretical knowledge and experience based on our own pedagogical practice in formulating the hypothesis:

Main hypothesis:
H: Students will achieve significantly better results in the final test at the end of the term.

The pedagogical experiment was performed on two different dates: experimental group in the 8th week of the term and the control group at the end of the term. Very same students participated on both dates. The time difference between the two tests was 5 weeks, during this period another issue of integral calculus was taught and students had the opportunity to re-examine and consult with a teacher. We identified the changes that had occurred due to changed conditions in the experimental group compared to the control group.

Another method we used in our research was the observation, the general aim of which was to identify other pedagogical phenomena - e.g. correctness of the used method, decomposition of the function, application of integral calculus in practice, etc. The aim of the research was to determine the level of knowledge of students in the field of integral calculus; to determine their ability to apply it when calculating double integrals and practical problems.

Location of the research: Faculty of Engineering, Slovak University of Agriculture in Nitra, 1st year students

Research period: winter semester 2018/2019
Testing content: There were four tasks in both tests. Every correct answer was worth six points or two points, an incorrect answer zero points. Examples of the test taken in the 8th week of the term (experimental group):

Example 1. Evaluate the following integral: $\int \left(\frac{2}{x^3} - \frac{6}{\sqrt{x}} \right) dx$

Example 2. Evaluate the following integral: $\int_0^1 \frac{x}{\sqrt{5x^2+4}} dx$

Example 3. Find the area between the curve $y = 3x$ and $y = x^2 - 4$.
Example 4. Write a Newton – Leibniz formula

Examples of the test taken at the end of the term (control group):

Example 1. Evaluate the following integral: $\int \left(\frac{4}{x^4} + \frac{3}{\sqrt[3]{x^4}} \right) dx$

Example 2. Evaluate the following integral: $\int_0^1 \frac{x^2}{(4x^3+1)^3} dx$

Example 3. Find the area between the curve $y = x^2 - 2x - 8$ and $y = 3x - 8$.
Example 4. Write a Newton – Leibniz formula

RESULTS AND DISCUSSION

Different statistical methods were used in processing the obtained results. We have processed the research results and presented them in the tables and graphs below. In our research 82 students participated. The main aim of our research was to identify the changes that occurred due to changed conditions in the experimental group compared to the control group.

The experimental group

There were 82 students in the experimental group. Table 1 shows the number of earned points, percentage score and the total number of points in the experimental group for each task.

Tab.1 Earned points in the test (experimental group)

Task No.	1	2	3	4	Total
100 % of points	492	492	492	164	1640
Earned points	294	260	238	87	879
Success rate in %	60	53	48	53	54

The above table shows that the lowest average success rate was achieved in the task No. 3: Find the area between the curves. The highest level of knowledge was found in the task No. 1: Convert square roots to exponents and evaluate the following integral.

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The control group

For 5 weeks students were studying another issue of integral calculus and had the opportunity to re-examine and consult it with their teachers.

Table 2 shows the number of earned points, percentage score and the total number of points in the experimental group for each task.

Tab. 2 Earned points in the test (control group)

Task No.	1	2	3	4	Total
100% of points	492	492	492	164	1640
Earned points	339	273	332	117	1061
Success rate in %	69	55	67	71	65

It is clear from the tables that in the control group the total success rate increased by 11 %. The task 2 was recorded as the most difficult one with the lowest average success rate. On the other hand, tasks 1 and 4 recorded the highest level of knowledge. Evaluation of success rate in individual tasks in both, the experimental and the control group is shown in the Figure 1.

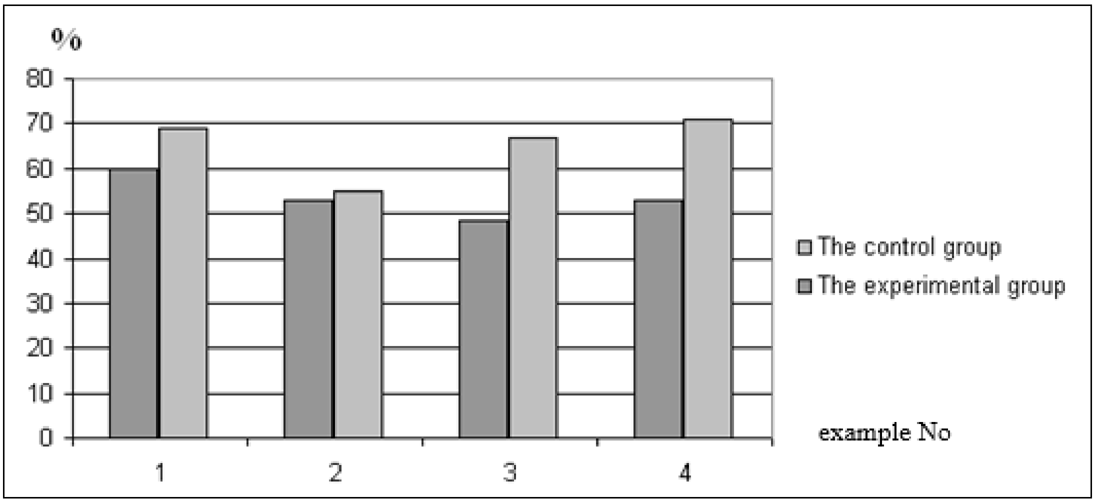

Figure 1: Evaluation of success rate in individual tasks

Testing equality of variances

We will test the hypothesis with the statement: the deviations in both groups are from the normal distribution. We can assume that members were assigned to individual test groups by random selection same compared to the hypothesis that the deviations are different.

An *F*-test is any statistical test where the test statistic has got an *F*-distribution which is lower than the null. *F*-test for the null hypothesis means that the two normal populations have the same variance. We have to handle this type of test very carefully, since it can be sensitive to the assumption that the variables have this distribution.

It is assumed that samples are realizations of random selections from the normal distribution $N(\mu_1, \sigma_1^2)$ and $N(\mu_2, \sigma_2^2)$ and the hypothesis to be tested explains that variances in both groups are equal, versus the hypothesis that the variances are different (Tab.3).

Test problem is: $H_0 : \sigma_1^2 = \sigma_2^2$ versus $H_0 : \sigma_1^2 \neq \sigma_2^2$

The F-test table brings $F = 1.602931$, the critical value where the level of significance is 0.025 and a test of significance is 1.444376, i.e., $F > Fkrit(1)$ and for this reason the equality of variances is rejected.

Tab. 3: *F*-Test for Equality of Two Variances

	Experimental group	Control group
Mean	10.71951	12.93902
Variance	12.40184	7.736977
Observations	82	82
F	1.602931	
P(F ≤ f) one-tail	0.017557	
F Critical one-tail	1.444376	

Testing the level of students' knowledge in control and experimental groups

The Two Sample Assuming Unequal Variances t-test will be used now in our research because the equality of variances has been rejected. We will test the null hypothesis, which says that the level of knowledge of the tested students is the same in comparison to the one-sided alternative hypothesis.

Our test problem: $H_0 : \mu_1 = \mu_2$ versus $H_1 : \mu_1 \neq \mu_2$

In the Table 4 we can see that the statistical value of the t-test is – 4.47865. A critical value for statistical significance is 1.654808. The hypothesis H_0 is rejected because Critical Value is smaller than the absolute value of the t-test.

The hypothesis proved that the average level of students' knowledge in the two groups was significantly different.

It is clear from the statistical evaluation that students' results were better in the test taken at the end of the term (control group) compared to the test taken in the 8th week of the term (experimental group).

Tab. 4: t-Test: Two Sample Assuming Unequal Variances

	Experimental group	Control group
Mean	10.71951	12.93902
Variance	12.40184	7.736977
Observations	82	82
t Stat	-4.47865	
P(T ≤ t) one-tail	0.0000728	
t Critical one-tail	1.654808	
P(T ≤ t) (2)	0.0000146	
t krit (2)	1.975488	

When analyzing the errors, we found that the students could not find the right method of integration (substitution). These errors can be eliminated by including integral functions in other areas of mathematics (differential calculus, definite integral, indefinite integral, differential equation), in which we use basic methods of integration. In Figure 1, we see that students who solved problems from the integral calculus during the next weeks of the semester achieved better results in all test tasks. This is the reason why the second (control) test at the end of the semester gave better results. The main problem in solving the problems was that the students could not find the right way to solve the tasks; the tasks were solved by incorrect methods - integration methods. The problem with using the substitution method was choosing the wrong function for substitution.

CONCLUSION

The results of the research showed the shortcomings that were caused by the preference of the studied thematic unit of integral calculus.

Students made various mistakes. We divided the errors into three categories:
- number errors deal with errors associated with derivatives and integrals,
- errors that deal with errors concerning exponents and roots,
- the algebraic manipulation errors represent errors that may occur when manipulating with functions.

The results showed that better results were achieved in the test taken at the end of the term (control group).

The aim is to improve and increase the level of knowledge of students by including new methods into the teaching process. These new methods are:
- to use illustrative examples when teaching integral numbers
- to specify new concepts in integral numbers in detail,
- to highlight incorrect procedures in solving integrals.

The learning process and, at the same time students' knowledge can be increased by the use appropriate teaching methods. One of the ways to eliminate incorrect mathematical procedures in students is to point out mistakes and look for ways to eliminate them.

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REFERENCES

[1] Dawson, R. (2019). *Integration by undetermined coefficients*. Retrieved 2020-07-09 from http://cs.stmarys.ca/~dawson/Undetermined.pdf

[2] Ferenczi Vaňová, S., Hornyák Gregáňová, R., Váryová, I. & Košovská, I. (2015). Analysis of motivation factors of students in selected subject at the FEM SUA in Nitra. *ICABR 2014*. Brno: Mendel University, pp. 181-190. Retrieved 2020-07-08 from http://www.icabr. Com/fullpapers/icabr2014.pdf

[3] Hornyák Gregáňová, R. & Országhová, D. (2017). Mathematical competences of students in solving applied problems. *EDULEARN 17*. Valencia: IATED, pp. 1656-1661. Retrieved 2020-07-09 from http://dx.doi.org/10.21125/edulearn.2017

[4] Kecskés, N. (2019). Evaluation of specific integrals by differentiation. *Mathematics in education, research and applications*, 5, 2 (2019), pp. 98-103. doi: https://doi.org/10.15414/meraa.2019.05.02.98-103

[5] Országhová, D. (2017). The application of computational tools of it in mathematical tasks. *Effective Development of Teachers' Skills in the Area of ICT.* Katowice: University of Silesia, 2017, pp. 438-448.

[6] Országhová, D., Fľak, P. & Papcunová, V. (2018). Tertiary education system in Slovakia. *International scientific days 2018*. Praha: Wolters Kluwer ČR, pp. 1995-2009. doi: https://doi.org/10.15414/isd2018