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Original Paper

Study results comparison in Mathematics with English language of instruction

Dana Országhová *

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Mathematics, Nitra, Slovak Republic

ABSTRACT

At the Slovak University of Agriculture in Nitra mathematical subjects are included in study programs, which are taught in English. The main goal of the paper is to compare the education results in the study course Mathematics with English language of instruction. We focused on the level of mathematical competencies of students in solving selected problems from linear algebra and mathematical analysis. The research sample was composed of the first-year students of English study program Regional Development and Policies of the EU. Empirical data were obtained from partial tests, exam tests and final grades in the exam in Mathematics in the academic years 2015/2016 to 2019/2020. Data analysis was performed by descriptive statistics and using non-parametric one-sample Wilcoxon test. We found that in the group taught in English, students achieve better exam grades in Mathematics than students taught in Slovak. Results of hypothesis testing have not proved the significance of differences in the gained point score of individual tasks in the analyzed study group.

KEYWORDS: Mathematics, teaching in English, exam grades, one-sample Wilcoxon test

JEL CLASSIFICATION: D40, C50, M10

INTRODUCTION

The working career of every person is conditioned by the level of education and acquired specialized competences. The training of students in economics study program is important for their employment and work in firms, trade companies, services, etc. Graduates will perform activities in various areas such as organizing, planning, leading, decision-making, and control, which are important for the success and application of the company in the competition in the labor market. The content of economic study programs also includes

* Corresponding author: Assoc. prof. RNDr. Dana Országhová, CSc., Slovak University of Agriculture, Faculty of Economics and Management, Department of Mathematics, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: dana.orszaghova@uniag.sk

mathematical subjects that provide exact tools and procedures for solving theoretical and application problems.

The university study in a foreign language at Slovak universities brings new possibilities for professional employment of graduates, provides students with opportunities to acquire new professional and language competencies. As Gálová et al. [3] report the internationalization extends interest of students in education at university level. The completion of studies in foreign language brings new value to the quality of education and development of competencies through mobility projects [6]. Study stays abroad and summer work activities are pre-conditioned with mastery of standard communication in a foreign language and also with understanding of scientific terms [11]. The teaching of mathematics in a foreign language is based on the general language training of students and teachers [12]. Direct experience from mathematics teaching in English confirmed that the content and method of mathematics teaching in English-speaking countries may differ from the content and didactic methods used in other European countries [9]. For teaching in English, it is important to create study materials in printed and electronic form and apply effective tools of information technology for the knowledge transfer from teachers to students [4].

Educational process is a result of many factors interaction (subjects of education, means, and conditions of education) and their analysis results in new findings. According to Khakpour [5] universities are the important institutions for the constant dissemination and pursuit of knowledge. Universities and faculties transform and transfer knowledge resources through the teaching, research, publications, operation and assessment.

In research studies, mathematical abilities and mathematical skills are often the subject of analysis. Cígler [1] deals in details with mathematical abilities and mathematical skills, stating the main differences, ways in which they arise and could be measured. Results of didactic research in different countries have confirmed that students' interest in science subjects is decreasing and students come across difficulties in STEM subjects (i.e. science, technology, engineering, and mathematics) [14]. Mathematical knowledge becomes permanent only if students sufficiently understood math terms with its logic meaning and processed them in mind adequately [10]. The important part in explanation is the visualization of new math concepts, which facilitates the main idea of concepts and could shorten the learning process itself [2]. To support learning in depth it is important to combine new mathematical concept with solving applied problems [13].

MATERIAL AND METHODS

In this paper we focused on the comparison of final exams in Mathematics, students' knowledge level and their ability to solve tasks in this compulsory study subject. Research sample consisted of students of the Faculty of the Faculty of European Studies and Regional Development, Slovak University of Agriculture (SUA) in Nitra. We got sources for this paper by studying the specialized articles and literature related to the pedagogical research. The next research material was obtained from the teaching process.

The subject Mathematics is included in the winter semester in the bachelor's study program Regional Development and Policies of the EU and the scope of teaching is 1 hour per week lecture and 3 hours seminar. During the semester, students submitted a seminar project, wrote one partial test and one final exam. In the individual academic years from 2015/2016 to

2019/2020, study groups contained a small number of students, so together we analyzed 27 partial and exam tests.

In evaluation of data we used descriptive statistics and via one-sample Wilcoxon test we tested the significance of differences between gained points in solved math problems. The null hypothesis states that distributions of characters *X*, *Y* are the same; the alternative hypothesis claims that distributions of analyzed characters *X*, *Y* are not the same. We assume that quantitative characters *X*, *Y* have continuous distribution functions. Then we determine differences $x_i - y_i$ $(i = 1, 2, ..., n)$ for empirical data (x_1, y_1), (x_2, y_2), ... ,(x_n, y_n) and arrange them in a non-decreasing sequence, omitting the zero differences. We find the sum of the orders of positive differences (value *T*+) and the sum of the orders of negative differences (value *T*–). The value of the test statistic is defined as $T = \min(T_+, T_-)$. If the value of the test criterion is less than or equal to the critical value $w_n(\alpha)$, then we reject tested null hypothesis at the chosen level of significance α [7].

RESULTS AND DISCUSSION

Exam grades in study subject Mathematics

In this part we analyze study outputs in Mathematics of mentioned study program in years 2015/2016 to 2019/2020.

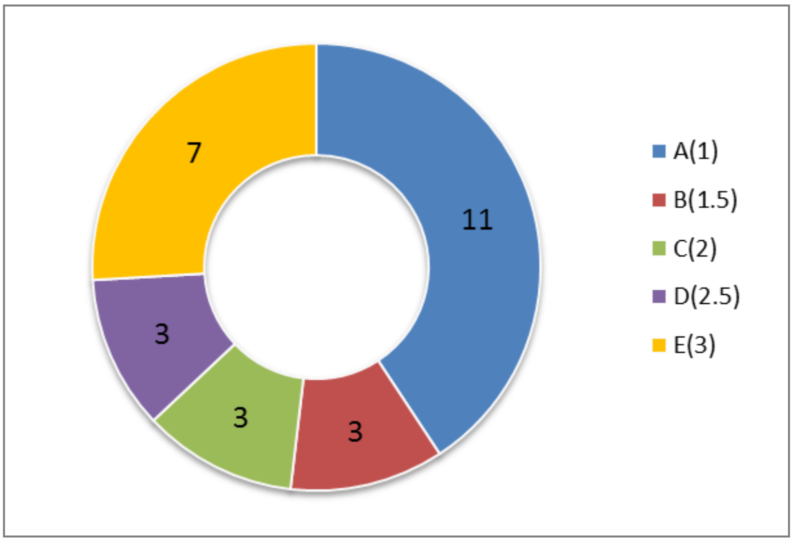

Fig. 1 Exam grades in Mathematics taught in English, years 2015/2016 – 2019/2020
Source: author

As we mentioned above, overall number of students was 27 in all groups with English language of instruction. According to Fig. 1 we see, grade A (1) was achieved by the largest number of students (11 in total), followed by grade E (3) (7 students).

In Tab. 1 we present the average grades in Mathematics within five academic years for study groups taught in English (EG) and for groups taught in Slovak (SG). In the last column we also listed the numbers of students in each group. From data we see that approximately one tenth is represented by students in the group with English language of instruction. The values show that the study average in the EG group was better each year than the study average in the SG group, which is also valid when comparing the study averages for all years together.

Tab. 1 Comparison of average grades and numbers of students

Academic year	English group Average grade	Slovak group Average grade	Number of students EG/SG
2015/2016	2.31	2.39	8/75
2016/2017	1.75	2.25	4/55
2017/2018	1.67	2.28	3/39
2018/2019	1.42	2.25	6/55
2019/2020	1.83	1.96	6/42
Overall	**1.85**	**2.25**	**27/266**

Source: author

The calculated average grades for the English groups are demonstrated in graphical form (Fig. 2). We see that in the individual years, the average exam mark gradually improved, while it decreased again in the last year. Only in the academic year 2015/2016 the study average in mathematics (2.31) was worse than the overall average for all years (1.85). In the group, Slovak and foreign students are together, while foreign students complete one or two semesters at the selected faculty as a part of the Erasmus+ stay. These are usually students with excellent study results and their motivation to achieve good exam grades is also high so that they would obtain a scholarship after returning to their home university. Exactly these students improve the final study results of the group taught in English.

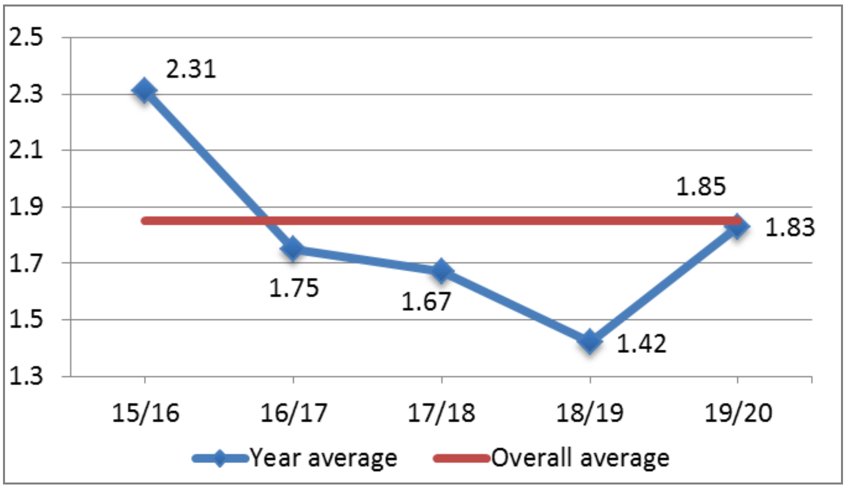

Fig. 2 Average grades in Mathematics taught in English
Source: author

Tasks analysis of mid-term and exam tests

In this part we present an analysis of students' success in solving selected problems in mathematics. From mid-term tests and exam tests, we selected two tasks from linear algebra (Task 1, Task 2) and two tasks from mathematical analysis (Task 3, Task 4):

Task 1: Solve the system of linear equations by elimination method.
Task 2: Find inverse matrix.
Task 3: Sketch graph of a function and write its properties.
Task 4: Find monotonicity and local extremes of function with usage of derivative.

We arranged the point scores from the problem solving into pairs and using the Wilcoxon one-sample test we tested the hypotheses about the distribution of the investigated characters (Tab. 2). The last analyzed pair was created from a set of tasks on linear algebra together (Task 1, Task 2) and a second set of tasks on functions together (Task 3, Task 4). The value n expresses the number of non-zero differences in the set of tested data, referred to in the literature as the effective sample size. Based on results we conclude that in all seven cases the calculated test statistic is greater than critical value $w_n(\alpha)$ for $\alpha = 0.05$. Therefore, we cannot refuse null hypothesis at chosen significance level which means analyzed data have the same distribution function. In the research sample, no significant differences in the point score between the individual task pairs were confirmed.

Tab. 2 Results of Wilcoxon one-sample test, $\alpha = 0.05$

X	*Y*	*n*	*T*+	*T*–	$w_n(\alpha)$	Result
Task 1	Task 2	22	176	**77**	65	$77 > w_n(\alpha)$
Task 1	Task 3	21	169.5	**61.5**	58	$61.5 > w_n(\alpha)$
Task 1	Task 4	16	98.5	**37.5**	30	$37.5 > w_n(\alpha)$
Task 2	Task 3	22	150.5	**102.5**	65	$102.5 > w_n(\alpha)$
Task 2	Task 4	22	130.5	**122.5**	65	$122.5 > w_n(\alpha)$
Task 3	Task 4	20	**94**	116	52	$94 > w_n(\alpha)$
Linear algebra	Functions	43	587.5	**358.5**	310	$358.5 > w_n(\alpha)$

Source: author

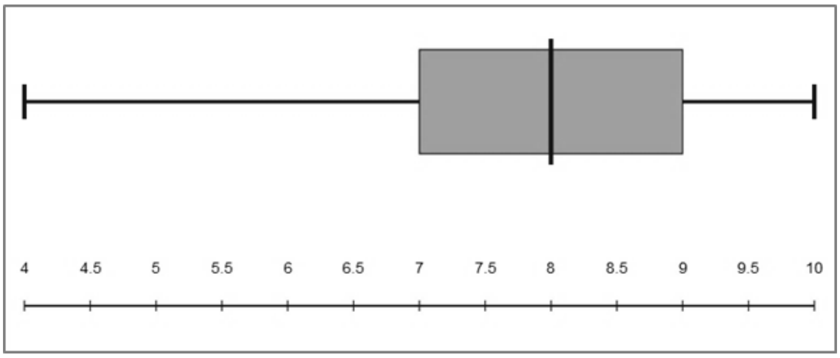

Fig. 3 Points rate for tasks from linear algebra together
Source: author

Fig. 3 shows a box plot for points obtained for problems from linear algebra together. The median of this set is 8, the mode is also 8, and the average number of points is 7.94. In Fig. 4 we present a box plot for the obtained points for the mathematical analysis problems together. The median of the file is 8, the mode is 10, and the average value of the gained points is 7.43.

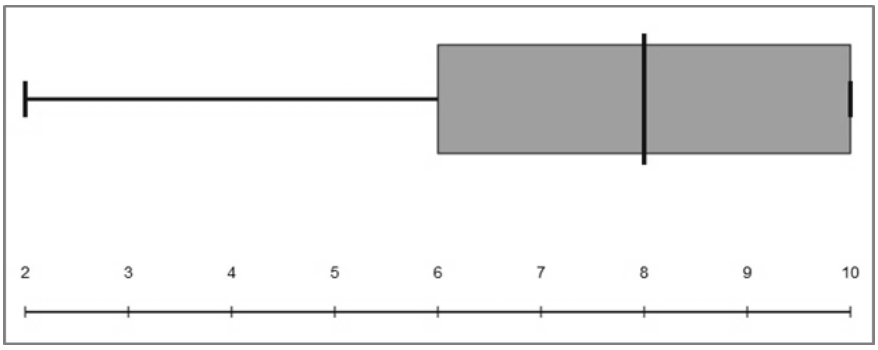

Fig. 4 Points rate for tasks from mathematical analysis together
Source: author

Some problematic factors in the study of mathematics have been identified directly from teaching. Linear algebra is included in the content of analyzed subject at the beginning of the semester, i.e. during the preparation for the exam students study this part better and longer. Functions and derivatives of function are included in the second part of the course; therefore in case of poor study organization for the exam, students will not be able to handle this part just as well. Negative factors include lower knowledge of high school mathematics, frequent numerical errors, misunderstanding of the assignment and students' inattention during tests.

The deterioration of study outcomes in mathematics in tertiary education is also claimed by Matušek and Hornyák Gregáňová [8]. University studies are based on working with knowledge that is most often accessible in the text form. As Průcha [15] states, the correct interaction between the text and its reader is essential for understanding the information in the text. Understanding a mathematical text is also associated with the logical thinking of an educated person and with a sufficient number of hours to practice new topics.

CONCLUSIONS

The main aim of tertiary education is to equip students with knowledge and skills important for real life and their future professions. Rapid changes in the work process and the digitization of work activities must be reflected in the new competencies of university graduates and in modern methods of education, which also include the offer of study programs in English.

In this paper we presented the analysis of study outcomes in the subject Mathematics, taught in English at the Faculty of European Studies and Regional Development SUA in Nitra. The results demonstrate that students successfully complete the study of mathematics in English. We evaluated mathematics exam grades, where analyzed study group achieved a better grades average in comparison with study groups taught in the Slovak language. When comparing the level of point scores in problems from linear algebra and mathematical analysis, statistically significant differences were not confirmed using the one-sample Wilcoxon test.

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