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Original paper

Pedagogical and statistical analysis of students' mathematical and language competences

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ABSTRACT
The current trend at universities is to offer to students the study programs with the subjects taught in English. We are interested in the facts what competences and associated learning outcomes can be achieved by the students. Therefore, the main objective of this paper is the pedagogical and statistical analysis of the study outcomes. We have decided to compare the examination results of the selected subjects and determine whether study outcomes of the subjects are statistically dependent. We have obtained the data for the analysis from the compulsory subjects of Mathematics (taught in English and in the Slovak language) and from the subject English for Specific Purposes I. We have analysed the results of the study groups from the Faculty of European Studies and Regional Development at the Slovak University of Agriculture in Nitra.

KEYWORDS: mathematics, English, statistical dependence, χ^2-test

JEL CLASSIFICATION: D20, D40, M10

INTRODUCTION

The contemporary professional and scientific practice emphasizes the requirements for the students to be able to communicate in a foreign language. Apart from the common social communication it is important that the students could acquire new information and present the professional knowledge in a foreign language. The ability to communicate in a foreign language is becoming the significant advantage for any person looking for the appropriate job at the labour market. Therefore, teaching subjects in a foreign language means the excellent opportunity for the connection of a language and professional knowledge in the particular subject.

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Apart from the study of a foreign language many universities offer to the students the study programs with the specialized subjects taught in English. The Slovak University of Agriculture (SUA) in Nitra also provides teaching in English for some study programs. It means that the mathematical subjects are taught in English, as well. We have researched the study results of the students who have studied mathematics in English and the interdependence between the study results in English and mathematics. We want to compare these findings with the results of those students who have studied mathematics in the Slovak language. We will test the statistical hypotheses and thus we will verify if there is the statistical dependence between the final grades at the exams of the subjects Mathematics and English for Specific Purposes I.

The teachers of the Department of Mathematics teach the subject Mathematics in Slovak and in English the students in the first year of the bachelor level at the Faculty of European Studies and Regional Development at the Slovak University of Agriculture in Nitra. The students are obliged to complete their course by the exam. The principal objective of the course is to teach the students the mathematical apparatus and the methods of solving mathematical and application assignments that can be useful in the specialist subjects. The assignments with the application elements have impact on:

- The students´ motivation to study also the theoretical methods of mathematics,
- Development of students´ creativity,
- Knowledge durability,
- Connection of the mathematical theory and its practical application.

The objective of teaching English for Specific Purposes I (ESP) in the specialized study branch the European Development Programs at the Faculty of European Studies and Regional Development (ESRD) is the acquisition of the specific terminology, syntactic structures and methods of presentations with the topics of the international organizations and European institutions. Ellis and Johnson [2] (2009, p. 35) state that learners need to acquire the following qualities and skills:

- Confidence and fluency in speaking,
- Skills for organizing and structuring information,
- Sufficient language accuracy to be able to communicate ideas without ambiguity and without stress for the listener,
- Strategies for the following main points of fast, complex, and imperfect speech,
- Strategies for clarifying and checking unclear information,
- Speed of reaction to the utterances of others,
- Clear pronunciation and delivery,
- An awareness of appropriate language and behaviour for the cultures and situations in which they will operate.

Recently the special attention is concentrated on the ESP teaching via CA-CLIL (Computer Assisted Content and Language Integrated Learning), which means the implementation of information and communication technologies into the educational process where the different subjects are being taught in foreign languages. According to Veselá [9] (2012, p. 30) the main characteristics of CLIL are the following:

- Input-based,
- Learner-centred,
- Task-based,
- Content-oriented,
- Meaning-focused.

An analysis of the characteristics of education and educational institutions of the third millennium shows that predominant features are flexibility, inclusiveness, collaboration, authenticity, relevance and extended institutional boundaries. Roles of both students and teachers have changed significantly as educational goals have broadened to include lifelong learning, global interaction, the acquisition of meta-cognitive knowledge and skills, and processes include negotiated curricula and real-life tutors and informants. This is a demanding package that appears to lead us naturally to a social constructivist paradigm for learning and teaching [3].

Main aim of the teaching of mathematics at faculties of SUA in Nitra is to enable students to understand the importance of the mathematics as a mean of solving problems in other specialist subjects [7], [8]. Career opportunities for graduates are wider if they are educated in foreign language communication [4]. The evaluation of the educational level and quality is possible to carry out according to the different criteria where the exam results are just some of them. Therefore we have decided to analyse the exam results of the group where Mathematics was taught in English and compare them with the group taught in Slovak.

MATERIAL AND METHODS

The theoretical sources for the paper were the professional papers and publications which deal with the educational research and with the use of the statistical methods in this research [1], [5], [6]. Another source of the material was the experience and knowledge from teaching of Mathematics and English for Specific Purposes I in the first year of the undergraduate study at SUA in Nitra. This paper aims to analyse the study results of the above mentioned subjects by the methods of mathematical statistics.

During the last two years a survey at the Faculty of ESRD SUA was realized. The main objective was to compare the level of mathematics knowledge of the students from two groups: one group of undergraduates was taught mathematics in English and the second group in the Slovak language. We also analysed the results of the final tests in the subject English for Specific Purposes I. For the analysis and evaluation of the survey results the contingency tables and chi-square test of independence were used. The statistical sample included students from the Faculty of European Studies and Regional Development (of the Slovak University of Agriculture in Nitra), in particular, a group of students of the accredited study program European Development Programs in the bachelor degree.

The contingency tables allow testing of the various hypotheses. One of the hypothesis testing is a test of independence, which is used to assess the dependence of two qualitative variables measured on the elements of the same sample. The differences between the analysed and expected values of frequencies are assessed by the statistical criterion χ^2 (chi-square). We find out the statistical significance of the test (*p*-value) via the functions in MS Excel. If this value is less than 0.05, then the null hypothesis is rejected. This means that the probability that the observed differences and dependencies arose randomly, is less than 5%.

In general, we have the statistical sample of range *n* and we investigate two statistical attributes – the first one signed by *X* is the test mark of the subjects Mathematics (taught in Slovak and English language), the second one signed by *Y* is the test mark of the subject English for Specific Purposes I, both are taught in the 1st year of study. The primary table for quantitative characteristics is a sequence of the ordered pairs of values, which are further sorted out into contingency table of two-dimensional frequency distribution. The criterion χ^2 tests the null hypothesis, which expresses the independence of variables:

- Null hypothesis: Attributes *X* and *Y* are independent,

- Alternative hypothesis: Attributes *X* and *Y* are dependent.

We realized the selection by the single survey, non-anonymously, and then we registered marks in the table with the usage of MS Excel 2010. Next, the list was changed to anonymous (students appear in the tables just below the serial number). To preserve the objectivity of the dependency analysis and demonstrativeness of the used statistical methods, we explored the classification results of the academic year 2012/2013 and 2013/2014. In these years the test results have been consistently rated by the scale A (1), B (1.5), C (2), D (2.5), E (3) and FX (4). The option of the final evaluation FX (4) did not occurred in our statistical sample.

RESULTS AND DISCUSSION

In this section we present the results of the research. Based on described methodology we formulated and verified these two hypotheses for our statistical sample:
Null hypothesis:
The examination marks of Mathematics and English for Specific Purposes are independent.
Alternative hypothesis:
The examination marks of Mathematics and English for Specific Purposes are dependent.
We present the obtained results in the next section.

Tab. 1 Data of classification and result of testing - academic year 2012/2013

Observed frequencies – academic year 2012/2013			
	MAT A - C	MAT D - E	Total sum
ENG A-C	14	10	24
ENG D-E	1	3	4
Total sum	15	13	28
Expected frequencies			
	12.857	11.143	
	2.143	1.857	
Chi-test			0.216

Source: authors

Classification results in each contingency table were divided according to the criterion "better evaluation" (from A to C), "worse evaluation" (from D to E). In the Tab. 1 there are given the selected data from the academic year 2012/2013: ordered pair [*x*, *y*] where *x* is a marking of Mathematics (abbreviation: MAT) and *y* is a marking of English for Specific Purposes (abbreviation: ENG).

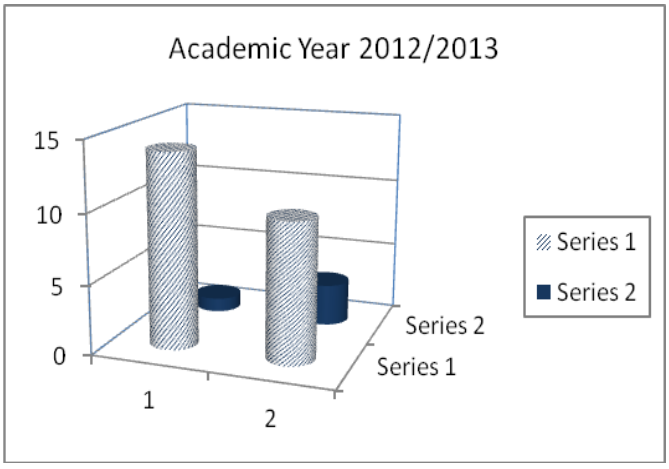

Fig. 1 Graphical representation of data. Source: Authors

In the Tab. 1 we have the result of chi-test realized by tools of MS Excel 2010. We received $p = 0.215869 > 0.05$. According to the used methodology the null hypothesis cannot be rejected. Thus, the examination marks of Mathematics and English for Specific Purposes I are independent.

The analysed data are also displayed graphically in Fig. 1. From the distribution of the data, we can see that the greatest frequency has a group of students with the better marks in English language (number 14). The second largest group is the group of students with the better exam marks in English and worse marks in mathematics (number 10).

Tab. 2 Data of classification and result of testing - academic year 2013/2014

Observed frequencies – academic year 2013/2014			
	MAT A - C	MAT D - E	Total sum
ENG A-C	7	11	18
ENG D-E	2	1	3
Total sum	9	12	21
Expected frequencies			
	7.714	10.286	
	1.286	1.714	
Chi-test			0.368

Source: authors

Now we will look over next data - in academic year 2013/2014 – which are summarized in the Tab. 2. Again we used ordered pair $[x, y]$, where x is a marking of Mathematics (abbreviation MAT as above) and y is a marking of English for Specific Purposes I (abbreviation ENG as above).

In the Tab. 2 we have also the result of chi-test. We received $p = 0.368066 > 0.05$. Therefore, the null hypothesis cannot be rejected. That means: the examination marks of Mathematics and English for Specific Purposes I are independent.

The data from the Tab. 2 are displayed graphically in Fig. 2. From the distribution of the data, we can see that the greatest frequency has a group of students with better marks in the English language and worse marks in mathematics (number 11). The second largest group consists of the students with the better exam marks in both subjects (number 7).

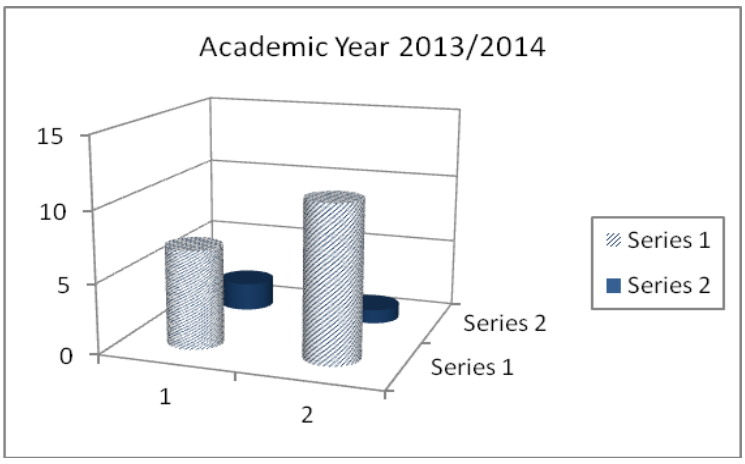

Fig. 2 Academic year 2013/2014. SourceAuthors

In the Tab. 3 there are collected data from both academic years: 2012/2013 and 2013/2014 with the important condition – the research sample consists of the students who studied Mathematics in English. Again we used ordered pair $[x, y]$ where x is a marking of Mathematics (MAT) and y is a marking of English for Specific Purposes I (ENG).

Tab. 3 Data of classification and result of testing - Mathematics in English (academic years together)

Observed frequencies – academic years 2012 – 2014			
	MAT A - C	MAT D - E	Total sum
ENG A-C	9	16	25
ENG D-E	0	2	2
Total sum	9	18	27
Expected frequencies			
	8.333	16.667	
	0.667	1.333	
Chi-test			0.299

Source: authors

In the Tab. 3 we have the result of chi-test. The achieved level of significance is: $p = 0.298698 > 0.05$. Again we can claim that the null hypothesis cannot be rejected. The examination marks of Mathematics and English for Specific Purposes I are independent in this special case, as well.
From the distribution of the data (see Fig. 3) we see that the greatest frequency (number 16) has this group: students with better exam marks in English for Specific Purposes I (from A to C) and worse marks in Mathematics (from D to E).

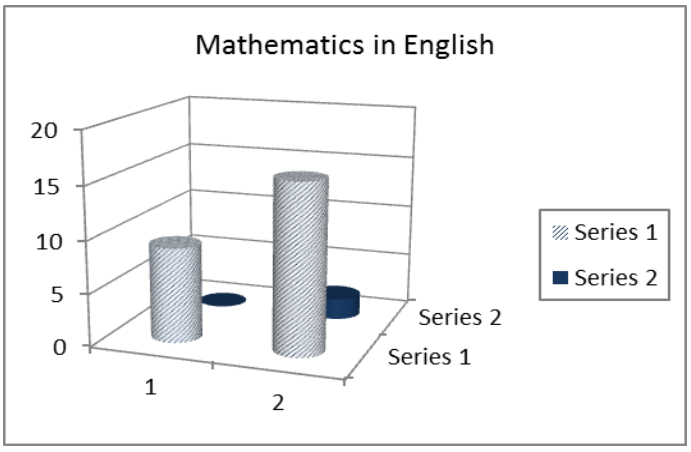

Fig. 3 Graphical representation of data. Source: Authors

The Figure 4 shows the arithmetic average of the marks for each study subject in a given academic year. The students achieved a better average mark in English for Specific Purposes I than in Mathematics. One important reason is that the thematic content of study of English is not as abstract as mathematics, which facilitates its understanding. There is not a greater difference in average marks in English for Specific Purposes I in given years. The average marks in Mathematics show the worsening of the level of students' competences in Mathematics.

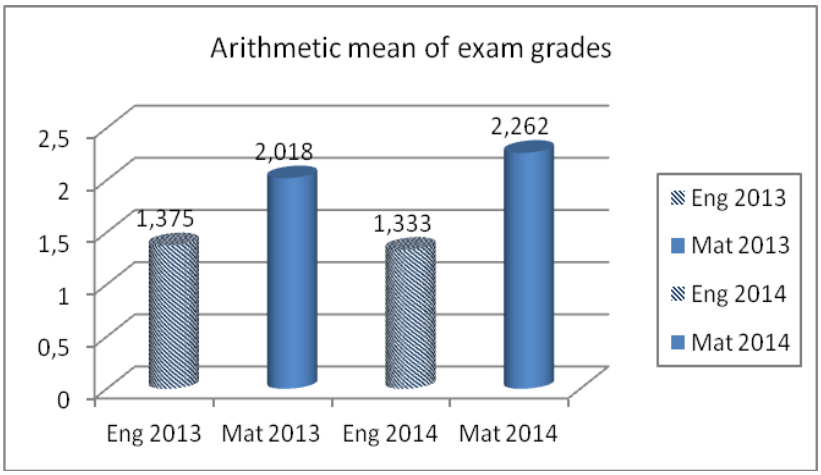

Fig. 4 Graphical representation of arithmetic means. Source: authors

CONCLUSIONS

The linguistic and mathematical competences belong to the obligatory equipment of students with economic specializations. The motivation for writing of this paper was finding the answer to the question whether there is any significant dependence between the examination grades of the two study subjects, namely from the subject English for Specific Purposes and Mathematics (which is taught in Slovak and English). Our methodological approach was based on one method of testing statistical hypotheses and we used it with the data obtained from the educational process.

In the tables we presented obtained results of testing hypotheses for each academic year 2012/2013, 2013/2014 and the data together in this period for Mathematics in English. We can summarize the results of statistical testing of hypothesis: The examination marks between Mathematics and English for Specific Purposes I are independent. According to the testing value *p* we cannot reject the null hypothesis.

Based on the statistical results and the graphical representation of the exam marks we can determine some of the principal indicators that can have an impact on these results. The compulsory subjects are taught in the first year of study and this could be associated with the students' adaptation to the university system. Our students come from the different types of secondary schools and they also have the different range of mathematical knowledge. Many of students assume wrongly that the university study will not contain the subject of Mathematics. Certain difficulties in the study of mathematics can be caused by the abstractness of math language and the content, as well. Moreover, the requirement of the self-study is difficult for some students, and this is reflected in the exams.

Finally, we can say that knowledge testing and assessment is the important part of the educational process. From the obtained data and their analysis it is evident that now we can be relatively satisfied with them. The current task of teachers should be – to keep the students' interest in these subjects and show the importance of applying of acquired competences from mathematics, as well as from English.

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