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STUDENTS' AUTOEVALUATION IN THE FIRST YEAR OF SCIENCE STUDY FIELDS ESPECIALLY IN MATHEMATICS (COMPLEX ANALYSIS)

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Abstract. This paper follows published results of the questionnaires that were done in 2010 and 2011. We continued in questionnaires next three years, however, collected data have not been published yet. We came back to them and decided to analyse them for the years 2011 – 2014 with purpose to check, if and how the observed parameters develop in a long-term horizon.

Keywords: mathematics, education, secondary school, university study

Mathematics Subject Classification: Primary 97A06; Secondary 97R06.

1 Introduction

In years 2009 – 2012, new Framework Educational Programmes (FEP) were implemented into School Educational Programmes (SEP) and schooling in the Czech Republic. Even though FEP describes compulsory and recommended extensional topics for each study field, it gives more freedom to schools in processing these topics into SEP in comparison to unified curriculum. Thus, huge differences in preliminary knowledge and skills occur between students, even at those from the same study field. This fact is visible in disunited knowledge in basic areas of Mathematics in first year students at universities, which influences the success in study. It was also the reason for making a questionnaire whose aim was to check the orientation in basic areas of Mathematics at students at the beginning of their studies and find, if there is any dependence of results on a type of absolved secondary school or if there are differences at students of different study fields.[4], [5]

Currently, thanks to amendment of Higher Educational Act, new study fields are being prepared at all Czech universities. It gives us unique opportunity to create study plans and edit content of subjects to make them correspond as much as possible with the profile of a graduate as well as with preliminary requirements on students. Thus, we decided to analyse data from questionnaires done in years 2011 – 2014[1] that have not been tested yet and use

[1] The questionnaire was slightly changed in 2011, it have not changed since then, thus we chose only data for four-year period.

these results in preparing new study programmes, when it is unique opportunity to create study plans and content of subjects to fit it the best to preliminary mathematical knowledge of students.

2 Description of the examination

Using the method Analysis of variance (ANOVA) we analysed results in 8 observed mathematical topics upon the secondary school attended and study fields:

- Sets and numerical fields (SET)
- Propositional logic and proofs (LOGIC)
- Functions (FUNC)
- In/equations (EQUAT)
- Fundamentals of the differential and integral calculus (MA)
- Combinatorics (COMB)
- Probability and statistics (STAT)
- Analytical geometry (GEOM)

Questionnaire is described in details in [4], [5].

Particular types of schools are the following: G - Gymnasium (preparation for university studies), SPS - industrial school (preparation for practice in several technical branches), SOS - integrated school (specialized branches for practice), OA - secondary business school (economically oriented for practice), SOU - secondary education for practice in a trade.

3 Results

Results in both evaluated years confirmed statistically significant differences in preliminary basic mathematical knowledge depending both on absolved type of school and chosen study field. [5]. We decided to check again, if these differences will be confirmed in a five-year term and we added to our analysis year-on-year comparison of results and mutual comparison of results between each areas. We used ANOVA, eventually MANOVA methods.

3.1 Results – dependence on a type of absolved secondary school

When evaluating ANOVA results from 2011 we found out statistically significant differences in total results (in all observed mathematical areas) depending on a type of absolved school [5]. Differences were also confirmed in 2014 with finding that results at SOU decreased much more. Also multiple comparison tests for all pairwise differences between the means identified statistically significant differences between types of school slightly differently.

Group	Mean 2011	Different from Groups 2011	Mean 2014	Different From Groups 2014
SOU	17,73214	SPS, G	14,5625	SPS, G
SOS	18,45821	SPS, G	18,79048	G
OA	20,44667		20,675	
SPS	22,10543	SOS, SOU	22,58833	SOU
G	23,71539	SOS, SOU	23,96364	SOU, SOS

Tab.1. Results of Tukey-Kramer Multiple Comparison test in 2011 and 2014 – differences between types of schools.

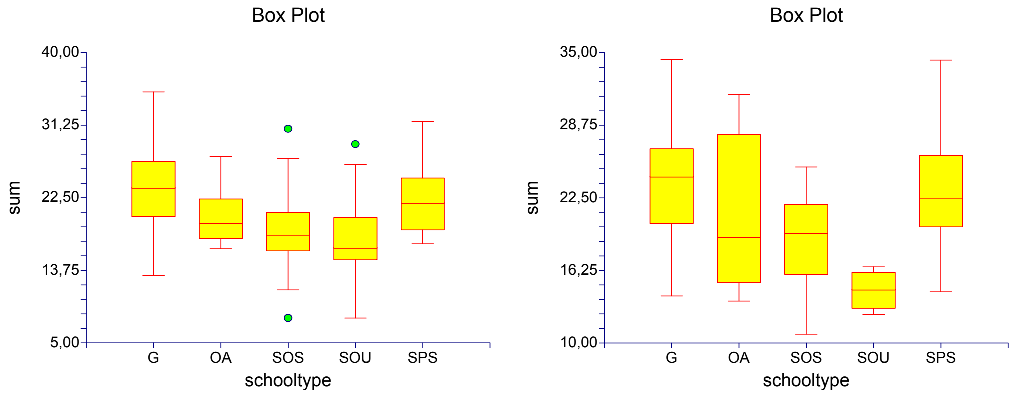

Fig. 1. Box plots in 2011 and 2014 – differences between types of schools.

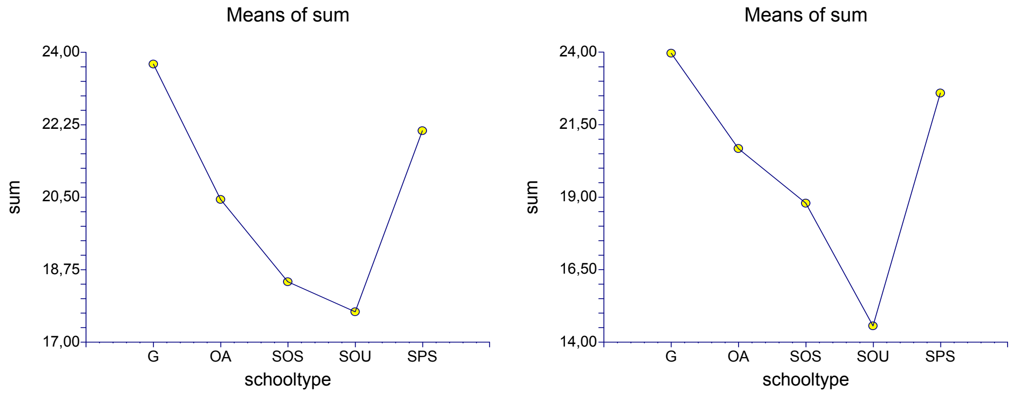

Fig. 2. Plots of mean in 2011 and 2014 – differences between types of school.

When we compared data for whole for-year period, differences between schools are visible again, collectively for all areas and in all areas as well. The best results were reached especially by graduates of G and SPS, namely in more areas together, however, in areas FUNC, SET and GEOM, students of G were slightly better, at areas STAT, COMB and MA, graduates of SPS reached same, even better results than graduates of G. Trend of giving more emphasis on differential calculus, combinatorics and statistics at industrial schools is being confirmed, which relates to the specialisations of study fields, that are taught there. In area EQUAT, students of OA approached in results to these two types of secondary schools. IN area LOGIC, results of students of G significantly outreached all other graduates, which relates to the fact, that only at this type of secondary school, the area of propositional logic and proofs is in compulsory topics in FEP.

3.2 Results – dependence on a chosen study field

With respect to the fact, that since 2012 data without geographical and biological fields were collected, in observed period 2011 – 2014 we focused only on comparison of fields, from which we have complete data, thus mathematical, informatics, physical, chemical and double-study field studies.

Group	Mean	Different from Groups
CH	19,23333	2ob, AME
AI	19,59242	2ob, AME
I	20,41167	
BF	21,6875	
AM	22,33077	
AME	22,63828	CH, AI
2ob	24,49211	CH, AI

Tab. 2. Results of Tukey-Kramer Multiple Comparison test in 2011 - differences between Study fields.

In 2011, ANOVA showed statistically significant differences in reached results of students of each study field (see Tab. 2), however in 2014 it confirmed zero hypothesis, which means that medians at each study fields are the same. We can say, that preliminary knowledge of applicants at observed study fields is in balance.

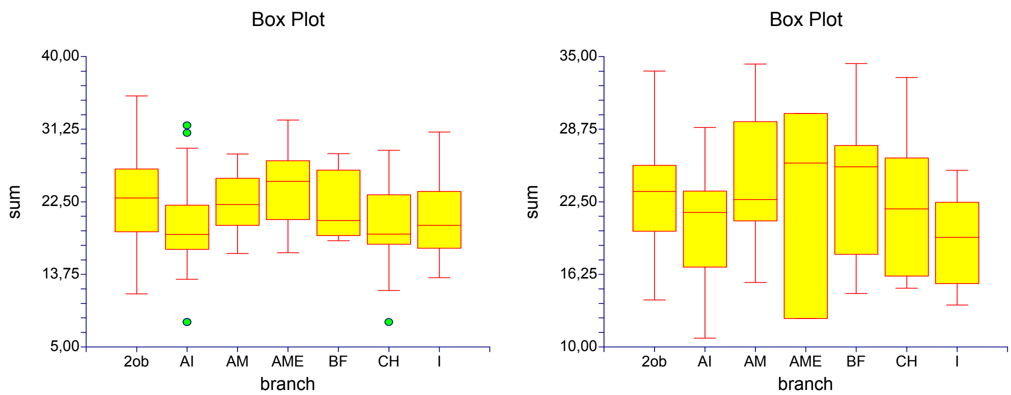

Fig. 3. Box plots in 2011 and 2014 – Differences between study fields.

3.3 Results in each observed mathematical areas

When analysing data in first two years, they were not yea-to-year compared as well as there was no comparison in achieved results mutually in each area. Thus, we focused on it now.

At first, we focused on year-to-year comparison. For each area, results from years 2011-2014 were compared and we observed, if there are statistically significant differences. We found out that results do not differ, except of two areas. Year-to-year results confirmed differences only in areas EQUAT and STAT.

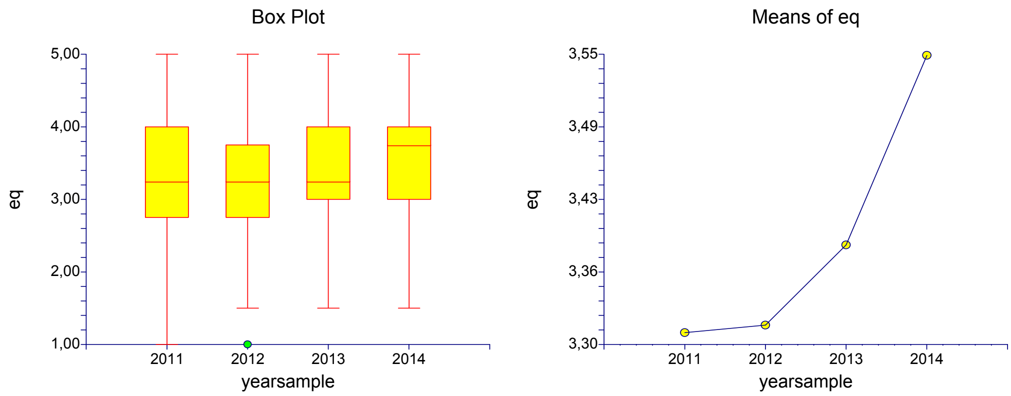

Fig. 4. Box plot and Plot of mean for the topic EQUAT.

Results in area EQUAT got significantly better in observed area, thus it is evident, that to this area, a great attention is paid at school. Tukey-Kramer Multiple-Comparison Test showed, that results differ conclusively in area EQUAT in years 2011, 2012 and 2014.

In area STAT, results in years 2011-2014 were also increasing, however, Tukey-Kramer Multiple-Comparison Test did not showed significant differences in comparison each pairs of years. Grouping was identified by different test, which identified differences between years 2011 and 2013, these tests are approximately accurate[2].

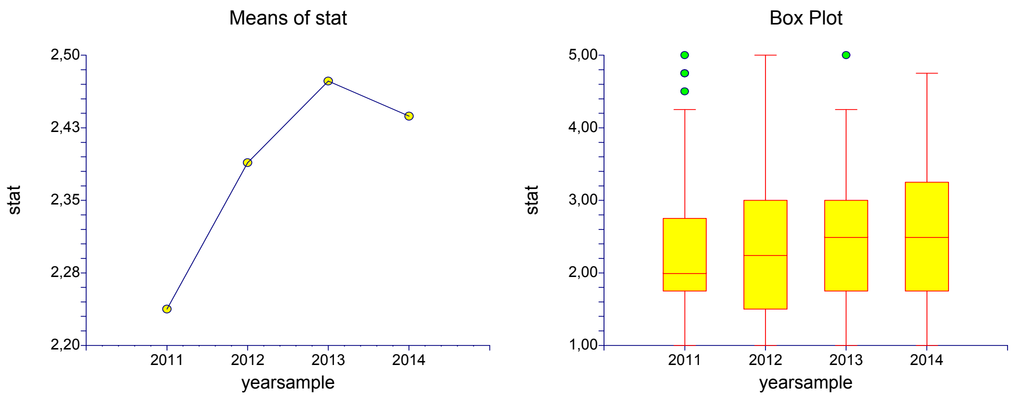

Fig. 5. Box plot and Plot of mean for the topic STAT.

At the end, we focused on comparison each area mutually. MANOVA showed, that there are statistically significant differences in knowledge at students in each area mutually. From graphs (Fig. 6) we can see, that the best results applicants show in area EQUAT, the worst in

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[2] Each of the Multiple Comparison Tests has some different properties, differing primarily in how they handle the magnitude of error 1 of the α (level of significance of the test) when testing. Some of the tests are rather conservative, ie. maintain the required level of materiality throughout the experiment under fairly free assumptions, and by making the appropriate decisions as a rule at a lower level of materiality, do not allow the probability of error α to rise uncontrollably. Other tests are rather liberal, ie. they are very likely to reject the zero hypothesis on the compression of the compared pairs of mean values (in other words, we can easily obtain the statistical significance of the difference between the tested pairs of mean values). However, it should be remembered that these resulting significances may sometimes be false because the liberal tests do not adequately modify (ie reduce) the significance level in testing the differences in individual pairs of groups. Therefore, the error of the first type α in the entire experiment may increase disproportionately. [1]

area logic, and they are not good at STAT as well. In second graph, we can see confirmed fact, that year-to-year results do not differ in each area, except of areas EQUAT and STAT.

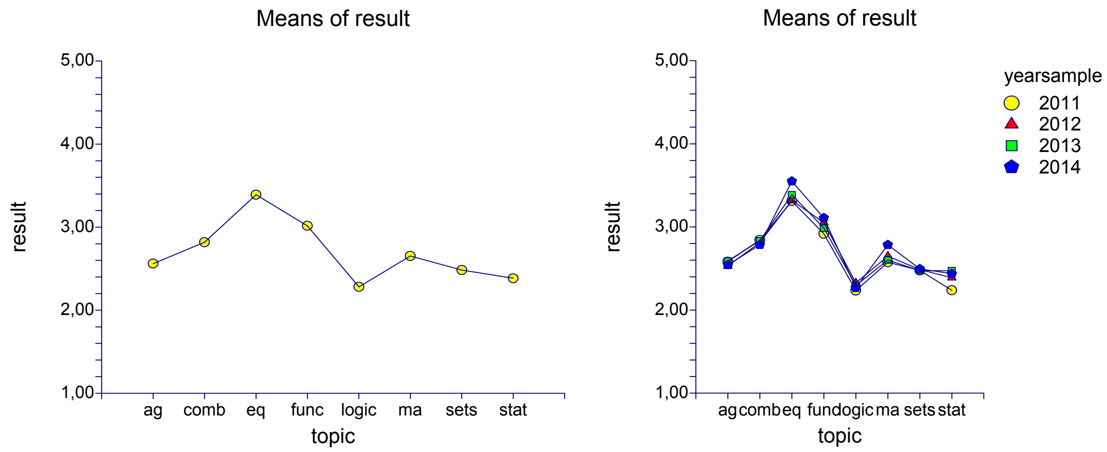

Fig. 6. Results of MANOVA – topics and years.

4 Conclusion

Evaluating the data from questionnaire for whole four-year period confirmed, that knowledge and orientation in basic mathematical areas between graduates of different types of secondary schools differs, which was expected. The best result is achieved by grammar school graduates and students of industrial schools, which corresponds with compulsory minimal lesson dotation of mathematics in FEP.

Less expected result was, that knowledge between students according to selected study field is getting into balance. It would be expected, that knowledge of students who enrolled at mathematical fields would be better than at other. It might be influenced by the character of fields included in questionnaire, physical, chemical and informatic fields belong into industrial programmes at which good mathematical literacy. Another effect is also the fact, that part of entrance examination on chemical and informatic study fields were requested entrance examination tests.

Results of third part were interesting. Knowledge of secondary school graduates do not differ in year-to-year comparison, with some exceptions, but the level of knowledge at each of eight areas of mathematics do differ.

Last two results can be used for the conception of new study programmes. E.g. where it is necessary for the next stage, it is necessary to include subjects containing the basics of mathematical statistics and propositional logic at the beginning of the higher education, while students in these areas cannot be expected to have sufficient secondary school base. With respect to the absence of differences between disciplines, such introductory subjects may be uniform for whole groups of disciplines and programs.

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