ANALYSIS OF DEPENDENCES OF E-LEARNING USAGE ON STUDY RESULTS

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Highlights

- *E-learning impact on the study results*
- *Dependence between results of full-time students and part-time students*
- *Dependences between results of students studying in two fields of study (Travel and Tourism, Finance and Management) in different years and subjects*

Abstract

This paper is aimed at the analysis of the study results of selected subjects of the full-time and part-time forms of study at the study programme Economics and Management that is offered at the College of Polytechnics Jihlava and covers two fields of study - Travel and Tourism, Finance and Management. The analysis extends and elaborates the findings from the paper Kuncova and Vojackova (2014). The first part of the study compares the results of the period before the start of the e-learning (2008 for full-time students and 2010 for part-time students) with the year 2012 (after the e-learning implementation) for both study fields. The second part is dedicated to the analysis of results of mathematical and statistical subjects. We have formulated 3 hypotheses for the first part concerning the dependence of the results on study year, form of study and study field. In the second part only first two hypotheses are relevant. The results from all selected subjects are tested via Chi-square test of independence. This comparison should answer a question if the e-learning had an impact on study results and if we can find dependence between results of two different types of study, two different years or two different study branches. The comparison shows differences of full-time and part-time students. However, we cannot prove the influence of the e-learning on the evaluation.

Keywords

Study results, Subjects, Comparison, Moodle, Chi-square test of independence

Introduction

Nowadays, e-learning forms an important part of studies at all colleges and universities in the Czech Republic. E-learning is usually prepared for students in distance study programmes to provide them more materials for the self-study. Clark and Mayer (2011) define e-learning as "*instruction delivered on a digital device such as a computer or mobile device that is intended to support learning*". Clark and Mayer also describe different features that e-learning might have such as the usage of various media elements to deliver the needed content (words, pictures, videos, sounds, presentations, CD-ROMs) or the inclusion of the instructional methods (examples, practice, feedback) to promote e-learning. Zounek (2011) thinks that the letter "e" will probably disappear from the word e-learning and usage of ICT will be ordinary during a learning process. The preparation of the e-learning courses is widely spread mainly because of new technologies and also in order to offer to students easily accessible materials for study.

Internet usage for learning and e-learning was widely spread in 1990s as WBT (Web Based Training). It was necessary to offer materials for studying. Moreover, for the necessity to manage on-line materials, new system was created. This system is known as Learning Management System (LMS) and is still used. Some of the LMS are prepared as open-source (Moodle), some are on commercial base - Edovo, UNIFOR, iTutor, Eden, eDoceo (Blahoz, 2013; Majerova, 2012). E-learning started to be integrated into the university education in the Czech Republic since 1999 at the University of Ostrava (Poulova, 2010). Since

2003 all Czech universities (except of art ones – such as Acadamy of Performing Arts in Prague, Academy of Fine Arts in Prague, Janáček Academy of Music and Performing Arts in Brno, Academy of Arts Architecture and Design in Prague) have been using some types of LMS systems. Nowadays, most of the Czech public universities and colleges (or so-called HEIs – Higher Education Institutions) use the LMS Moodle.

The comparison of students´ results connected to e-learning or distance learning is one of the topics that are mentioned in various articles. For example, Houska and Berankova (2011) studied an impact of additional contact lectures on students' results. Carnwell (2000) analysed the influence of e-learning materials usage instead of direct teaching. Carnwell found out an influence of well-designed e-courses with benchmarks and deadlines on the self-study. The impact of e-learning on study results was also tested by Popelkova and Kovarova (2013). These authors did not find any statistically significant relationship between results and final exam. Furthermore, Manochehri and Young (2006) also did not confirm significant difference in final evaluation in different forms of education. In this article we investigate the influence of e-learning, forms of study and years of study on the final evaluation. Three hypotheses concerning the independence of these factors are tested via Chi-square test of independence:

- H_0: There is no significant dependence between study results and selected years for particular subjects.

- H$_0$: There is no significant dependence between study results and study field (tested for particular subjects)

- H$_0$: There is no significant dependence between full- and part-time students´ study results.

The main aim is to find out if the e-learning usage has improved the results of study and changed the distribution of final marks.

Materials and Methods

The College of Polytechnics Jihlava has five accredited study programmes. One of the study programmes is Economics and Management. This programme covers two fields of study: Travel and Tourism (TT), Finance and Management (FM). In March 2014 more than 2600 students were enrolled in the full-time and combined forms of study in all programmes. 70% of the students studied in the programme Economics and Management. The part-time students represented 30% of all students. During the years 2009-2012 the project "Introducing E-learning System into Teaching and Creating E-Courses at College of Polytechnics Jihlava" subsidized from the Operational Programme Education for Competitiveness in the priority axis 2 with the project registration number CZ.1.07/2.2.00/07.0317 has been executed (https://www.vspj.cz/tvurci-cinnost-a-projekty/projekty/evropske/opvk). The main aim of the project was to create 150 e-courses in the learning management system Moodle. The project and its evaluation is discussed in the previous papers (Vojackova, Kuncova and Benesova, 2011; Kuncova and Vojackova, 2012; Kuncova and Vojackova, 2013). The e-courses were prepared mainly for the students from combined (a form of distance) form of study as well as for the full-time students. The e-courses do not contain only study materials, but also interactive homework or tests for students. The reasons of homework and tests and self-tests are to find out how students understand the topics.

In this article we would like to compare the study results of full-time and combined form students in selected subjects. One part of this comparison was mentioned in article Kuncova and Vojackova (2014). We are aware of the fact that the study results are influenced by a lot of different factors (such as learning style, personality traits, students' characteristics - (Kunstova, 2013)) and e-learning materials can be only one of them. But, on the other hand, we try to find out the differences between full-time and part-time students and between students from the two study fields (TT, FM) as all of them could use the same materials. So the first part of our research aims at the subjects that are obligatory for both study fields. Moreover, both study fields use the e-learning materials. These subjects are:

- Business Economy (BE)
- Macroeconomics (MAE)
- Marketing A (MGA)
- Microeconomics (MIE)
- Financial Accounting 1 (FIA)
- Public Finance (PF)

Five subjects (BE, MAE, MGA, MIE, FIA) are taught in the first year of study, PF is taught in the second year of the bachelor study programme. All these subjects end with the final exam mark on the scale A-F (A-E means the students have passed, F is for those who have failed). Each student has 3 attempts to pass the final exam. Therefore, we used only the final marks (the marks from the last term). For the comparison we use the percentage of students with each mark instead of real number of students as the numbers of students differ (from 60 to 500).

However, for the statistical tests we use the real data.

Firstly, we divided the students into field of study groups (TT and FM) to test the difference between their marks. Secondly, we divided students into the type of study groups to test the difference between full-time and combined form of study (Tab.1) as we cannot say that this difference is influenced only by the system of study (contact lessons and e-learning). The next part of our research is dedicated to the comparison of the results of the selected subjects over several years starting with 2008 (full-time) and 2010 (started the combined study form) – during this period no e-learning materials were available, and finished by 2012 (with all e-learning materials). Yearly results are taken from two semesters of study i.e. for 2008 we have taken results from the summer semester 2007/2008 and winter semester 2008/2009. All selected subjects are taught in both semesters during a year.

No. of student	full-time						combined form			
subject / years	2008		2010		2012		2010		2012	
	TT	FM	TT	FM	TT	FM	TT	FM	TT	FM
BE	304	213	678	597	326	199	157	452	168	159
MAE	285	176	294	245	259	188	0	156	125	100
MGA	317	176	265	233	286	196	0	144	128	99
MIE	283	423	440	334	332	204	161	216	166	155
FIA	295	188	276	259	310	200	0	144	95	107
PF	245	155	227	160	258	160	0	118	74	78

Table 1: Number of students in the selected subject (Travel and Tourism TT, Finance and Management FM), source: college information system

In all selected subjects we divided the numbers of the students with mark "F" into 2 groups – "F" written in Information system by the teacher and "F" written by Information system. Afterwards in all comparisons we excluded those who failed and had the mark "F" written in Information system by this system. It means that they did not try any final exam or test – those who tried the exam and failed have "F" in the system written by the teacher. The reason for the exclusion of these students is the fact that they probably did not use e-learning materials at all (especially in the first year of study students stop the attendance in the middle of the first semester). In the first year of study it is a lot of students (see Tab. 2-9).

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	1.27%	1.91%	1.06%	0.00%	0.92%
B	4.11%	7.64%	3.96%	2.38%	4.91%
C	14.24%	19.11%	17.41%	10.71%	12.58%
D	28.80%	22.93%	34.56%	13.69%	27.30%
E	20.25%	7.01%	9.23%	13.10%	24.54%
F	5.06%	4.46%	4.22%	19.05%	9.20%
F (from IS)	26.27%	36.94%	29.55%	41.07%	20.55%

Table 2: Business Economy (BE) results (Travel and Tourism TT study field), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	0.25%	6.82%	1.37%	1.26%	2.51%
B	3.70%	8.64%	7.53%	3.77%	2.51%
C	11.11%	13.18%	24.32%	8.81%	15.58%
D	22.72%	15.00%	24.66%	13.21%	22.61%
E	17.53%	5.00%	9.93%	15.72%	24.12%
F	12.35%	5.00%	1.03%	17.61%	11.06%
F (from IS)	32.35%	46.36%	31.16%	39.62%	21.61%

Table 3: Business Economy (BE) results (Financed and Management FM study field), source: college information system

Mark	2008 full-time	2010 full-time	2012 comb.f.	2012 full-time
A	5.61%	3.74%	0.80%	4.25%
B	9.12%	8.16%	8.80%	16.22%
C	20.70%	11.90%	21.60%	22.78%
D	10.53%	20.41%	16.00%	16.22%
E	32.63%	17.69%	24.80%	12.36%
F	4.91%	6.46%	2.40%	3.86%
F (from IS)	16.49%	31.63%	25.60%	24.32%

Table 4: Makroeconomics (MAE) results (TT study field), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	5.68%	3.85%	1.22%	1.00%	3.19%
B	6.25%	11.54%	6.94%	12.00%	11.17%
C	16.48%	29.49%	13.88%	23.00%	20.74%
D	10.80%	24.36%	14.69%	16.00%	12.23%
E	38.07%	10.90%	20.41%	23.00%	19.68%
F	7.39%	3.85%	4.90%	0.00%	5.32%
F (from IS)	15.34%	16.03%	37.96%	25.00%	27.66%

Table 5: Makroeconomics (MAE) results (FM study field), source: college information system

For example in the course Business Economics around 20-30% of full-time students gave up this subject, for students of combined form the percentage is higher, around 40%. Tables 2 and 3 show the distribution of results of BE. For Macroeconomics (Tab. 4-5) there are some differences: as the combined form of study for the Travel and Tourism study field started in 2010 and the subject Macroeconomics is taught in the second semester we do not have any results for students from this study field for the year 2010. But compared to BE, the percentage of "F from IS" is similar.

The situation of the subjects Marketing A is similar to Macroeconomics from a TT combined form point of view. The students of TT study field combined form started to study also in 2010 and Marketing A belongs to their second semester (so to the year 2011 at first). From the Tab. 6-7 we see that the percentage of "F from IS" is lower than in previous subjects but there are still remarkable differences between full-time and combined forms of study.

Mark	2008 full-time	2010 full-time	2012 comb.f.	2012 full-time
A	17.03%	16.60%	4.69%	18.88%
B	16.40%	18.11%	7.03%	15.73%
C	17.98%	20.38%	22.66%	22.73%
D	13.56%	12.83%	10.94%	20.98%
E	18.93%	17.36%	21.09%	11.54%
F	4.42%	8.68%	3.91%	2.45%
F (from IS)	11.67%	6.04%	29.68%	7.69%

Table 6: Marketing A (MGA) results (TT), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	11.93%	7.64%	12.02%	7.07%	16.84%
B	11.36%	15.28%	9.44%	12.12%	16.33%
C	15.34%	31.94%	18.88%	16.16%	17.86%
D	11.93%	12.50%	16.74%	18.18%	15.31%
E	28.41%	6.94%	21.46%	22.22%	13.27%
F	5.11%	0.00%	9.01%	1.01%	5.61%
F (from IS)	15.91%	25.69%	12.45%	23.23%	14.80%

Table 7: Marketing A (MGA) results (FM), source: college information system

The subject Microeconomics belongs to the first semester for both study fields and maybe because of this fact it has again higher ratio of students that did not finished this subject especially in combined form. (Tab. 8-9).

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	8.48%	0.00%	1.51%	1.24%	7.27%
B	7.42%	3.61%	3.61%	9.32%	7.95%
C	9.54%	21.69%	17.17%	21.12%	11.14%
D	13.43%	12.05%	5.72%	18.01%	11.36%
E	22.97%	16.87%	21.39%	9.94%	19.09%
F	27.56%	4.82%	20.18%	0.62%	11.82%
F (from IS)	10.50%	40.96%	30.42%	39.75%	31.36%

Table 8: Microeconomics (MIE) results (TT), source: college information system

Mark	2008 comb.f.	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	0.00%	1.65%	3.23%	2.45%	3.70%	3.89%
B	6.56%	2.36%	6.45%	2.94%	6.02%	7.19%
C	21.31%	13.24%	11.61%	15.69%	16.67%	12.87%
D	3.28%	7.33%	10.32%	13.24%	12.04%	11.98%
E	27.87%	19.39%	25.81%	21.57%	11.57%	25.15%
F	4.92%	17.49%	5.81%	17.16%	0.46%	9.28%
F (from IS)	36.07%	38.53%	36.77%	26.96%	49.54%	29.64%

Table 9: Microeconomics (MIE) results (FM), source: college information system

Mark	2008 full-time	2010 full-time	2012 comb.f.	2012 full-time
A	5.61%	3.74%	0.80%	4.25%
B	9.12%	8.16%	8.80%	16.22%
C	20.70%	11.90%	21.60%	22.78%
D	10.53%	20.41%	16.00%	16.22%
E	32.63%	17.69%	24.80%	12.36%
F	4.91%	6.46%	2.40%	3.86%
F (from IS)	16.49%	31.63%	25.60%	24.32%

Table 10: Financial Accounting 1 (FIA) results (TT), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	5.68%	3.85%	1.22%	1.00%	3.19%
B	6.25%	11.54%	6.94%	12.00%	11.17%
C	16.48%	29.49%	13.88%	23.00%	20.74%
D	10.80%	24.36%	14.69%	16.00%	12.23%
E	38.07%	10.90%	20.41%	23.00%	19.68%
F	7.39%	3.85%	4.90%	0.00%	5.32%
F (from IS)	15.34%	16.03%	37.96%	25.00%	27.66%

Table 11: Financial Accounting 1 (FIA) results (FM), source: college information system

Subject Financial Accounting I belonged to the first semester for the students of FM and to the second semester for the TT students. The percentage of those who failed is lower than in Microeconomics and it can be caused by the fact that some of the students get the basic knowledge at the secondary school (or the combined form students in practice).

Mark	2008 full-time	2010 full-time	2012 comb. f.	2012 full-time
A	38.37%	18.75%	24.32%	28.29%
B	2.86%	0.00%	21.62%	14.34%
C	25.31%	12.50%	16.22%	10.85%
D	3.27%	12.50%	6.76%	16.28%
E	25.31%	50.00%	16.22%	22.48%
F	0.41%	0.00%	1.35%	0.00%
F (from IS)	4.49%	6.25%	13.51%	7.75%

Table 12: Public Finance (PF) results (TT), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	26.45%	8.70%	0.00%	37.18%	25.63%
B	3.23%	10.87%	14.29%	7.69%	12.50%
C	27.10%	26.09%	28.57%	8.97%	13.75%
D	4.52%	17.39%	14.29%	8.97%	16.25%
E	29.03%	21.74%	0.00%	24.36%	26.80%
F	1.94%	0.00%	14.29%	0.00%	0.63%
F (from IS)	7.74%	15.22%	28.57%	12.82%	4.38%

Table 13: Public Finance (PF) results (FM), source: college information system

The last subject included in the analysis is Public Finance which is taught in second year of study and it is last subject common for both study fields TT and FM. Except of the year 2010 at FM the results seems to be better than in previous subjects.

So the data in the previous tables shows us that differences between the students of the fields TT and FM seems not to be so significant, but the difference between forms of studies probably exists. To test the differences and based on the groups mentioned above we have formulated these hypotheses:

1. H_0: There is no significant dependence between study results and selected years for particular subjects.

2. H_0: There is no significant dependence between study results and study field (tested for particular subjects)

3. H_0: There is no significant dependence between full- and part-time students´ study results.

For the comparison we use Chi-square test for independence using categorical data (marks, field of study, type of study, year of study) and contingency tables (Kanji, 2006). The Chi-square test of independence uses the observed frequencies for each category (here for the marks) to calculate the expected frequencies. Afterwards the relative square difference for each category is calculated. All these differences are summarized. The sum is compared with the Chi-square distribution. If the null hypothesis is true the sum (test statistic) is drawn from this Chi-square distribution – so the sum is lower than the critical value of the Chi square distribution with given significance level (usually 0.05) and with (r-1) degrees of freedom where r is the number of rows (categories) – in case we have two data sets to compare. As it is possible to change marks from the scale A-F into numbers we also calculated the average mark for each subject and year, study field and type of study. We try to compare these average marks but the t-test and F-test that are usually used for the comparison of average or variance have limited validity and robustness in our case (violations of assumptions as no continuous data, non-normality of distribution) and must be taken with circumspection only as complement to the Chi-square test results. It is possible to use non-parametric Wilcoxon test instead t-test but as Guiard and Rasch (2004) proved, "there are more disadvantages than advantages in using the Wilcoxon test in place of the t-test".

The next part is aimed at the subjects that are taught only at the study field Finance and Management and students evaluate them as the most difficult to study. These are:

- Mathematics I (MAT1)
- Mathematics II (MAT2)
- Mathematics for Economists (MATE)
- Probability and Statistics (PS)
- Statistical Methods (STM)

Number of students that studied these subjects is in Tab. 14. Mathematics I was studied in the first semester, Mathematics II in the second semester, Mathematics for Economists and Probability and Statistics in third semester, Statistical Methods in fourth semester of bachelor study. That is why the numbers of students are falling down from MAT1 to STM as some of the students leave the college without finishing the study. From the 3 mathematical subjects the most difficult seems to be MAT1 (according to the opinion of teachers and according to the marks – Tab. 15). This is one of the reasons for some students to leave the school and do not finish this subjects – see Tab.15 where more than 60% of part-time students and more that 40% at full time had "F" grade from IS so they did not try any exam (if they tried and failed they get "F" from the teacher not from the IS). MAT2 and MATE were also difficult as the % of "F from IS" together with "F" is also high (Tab. 16, Tab. 17) but more students have "F" given by the teacher so they tried to pass the exam. The situation with PS subject is similar to MATE as a lot of student obtained "F" from the teacher and only a few of them

(except of the year 2012) gave up the subject.

No. of student	full-time			combined form	
subject / years	2008	2010	2012	2010	2012
MAT1	442	367	266	264	178
MAT2	174	228	196	106	95
MATE	194	240	208	133	104
PS	140	171	169	153	99
STM	135	166	149	19	89

Table 14: Number of students in the mathematical and statistical subjects (FM), source: college information system

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	4.75%	4.55%	3.27%	1.12%	1.13%
B	2.94%	3.79%	4.36%	2.25%	3.01%
C	6.11%	5.68%	5.45%	9.55%	9.77%
D	3.17%	7.20%	9.81%	8.43%	10.53%
E	8.82%	7.58%	19.62%	6.74%	24.81%
F	0.90%	4.55%	4.09%	9.55%	6.02%
F (from IS)	73.30%	66.67%	53.41%	62.36%	44.74%

Table 15: Mathematics I (MAT1) results (FM), source: college information system, own calculation

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	6.32%	4.72%	6.58%	2.11%	8.16%
B	4.60%	7.55%	9.21%	2.11%	12.73%
C	18.39%	17.92%	14.91%	14.74%	20.92%
D	1.72%	23.58%	12.72%	15.79%	13.78%
E	24.14%	26.42%	25.44%	24.21%	25.00%
F	44.83%	19.81%	31.14%	14.74%	3.06%
F (from IS)	31.03%	17.92%	21.05%	26.32%	16.33%

Table 16: Mathematics II (MAT2) results (FM), source: college information system, own calculation

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	2.58%	1.50%	5.83%	0.96%	7.21%
B	14.43%	4.51%	7.50%	0.00%	7.69%
C	13.40%	13.53%	17.92%	3.85%	11.54%
D	12.37%	9.77%	10.00%	8.65%	7.21%
E	17.53%	32.33%	24.17%	25.96%	25.48%
F	39.69%	38.35%	34.58%	60.58%	40.87%
F (from IS)	38.14%	13.53%	14.17%	16.35%	34.62%

Table 17: Mathematics for Economist (MATE) results (FM), source: college information system, own calculation

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	4.29%	0.00%	0.58%	0.00%	0.59%
B	19.29%	0.00%	3.51%	0.00%	2.96%
C	16.43%	3.92%	12.28%	2.02%	6.51%
D	32.14%	13.07%	21.05%	6.06%	18.93%
E	15.71%	33.99%	42.69%	27.27%	36.69%
F	12.14%	49.02%	19.88%	64.65%	34.32%
F (from IS)	11.43%	10.46%	4.68%	17.17%	24.85%

Table 18: Probability and Statistics (PS) results (FM), source: college information system, own calculation

The last subject (STM) belonged to the fourth semester of the study and so the lowest number of students studied it (especially in the combined form – Tab. 13). One of the reasons might be the fact that some students left the school, another reason is that they had failed in previous subjects (PS or MATII or MATE) and so they had to study these subjects before STM. On the other hand those who studied STM were mostly successful (Tab. 18).

Mark	2008 full-time	2010 comb.f.	2010 full-time	2012 comb.f.	2012 full-time
A	3.15%	5.26%	1.81%	2.25%	0.00%
B	10.24%	10.53%	12.05%	11.24%	4.70%
C	30.71%	5.26%	31.33%	10.11%	19.46%
D	31.50%	15.79%	34.34%	12.36%	33.56%
E	18.90%	52.63%	16.87%	53.93%	38.93%
F	5.51%	10.53%	3.61%	10.11%	3.36%
F (from IS)	3.15%	10.53%	3.01%	3.37%	2.68%

Table 19: Statistical Methods (STM) results (FM), source: college information system, own calculation

We are interested in the dependencies on the study form and also on the year of study. So the hypotheses are similar as before and are followings:

- H_0: There is no significant dependence between study results and selected years for particular subjects.

- H_0: There is no significant dependence between full- and part-time students´ study results.

Results

The results from Macroeconomics (Fig. 1) are nearly normally distributed (according to the Kolmogorov-Smirnov test) and they are similar for the full-time type of study and in the combined form. In the full-time form the results in 2012 and 2010 were better than in 2008 where a lot of "E" marks were given. On the other hand, the results of combined students seem to be worse in 2012 than in 2010. The teachers were still the same, as well as the final test. So there was no influence of the different teachers. If we look at the results of Financial Accounting (Fig. 2) the normality test does not confirm the normality of the final marks distributions. The skewed distribution is given by the conditions (valid from 2008 till now) that the minimum percentage for the success in this subject (studied in the second year of study) is 70 %. On the other hand, to succeed in Microeconomics or Macroeconomics at least 60 % is required.
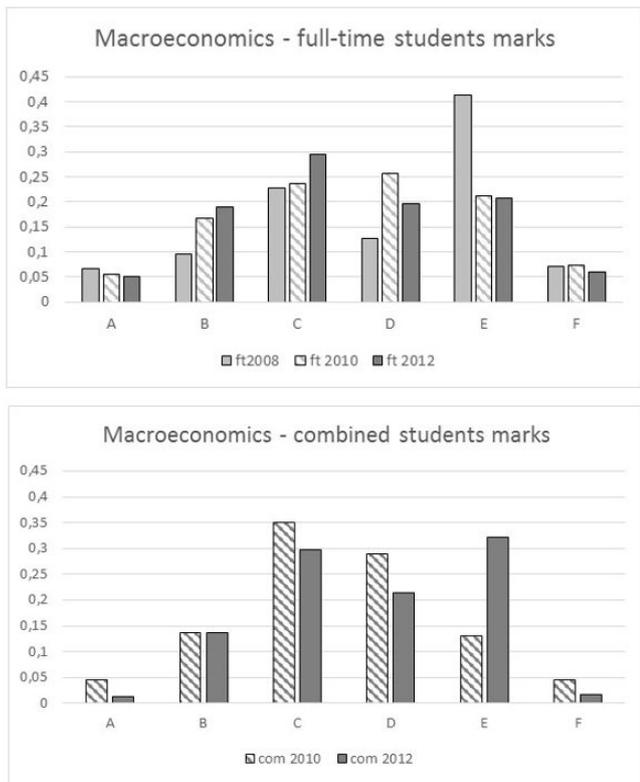
Figure 1: Macroeconomics – comparison of results (% of students with given mark), source: own calculations
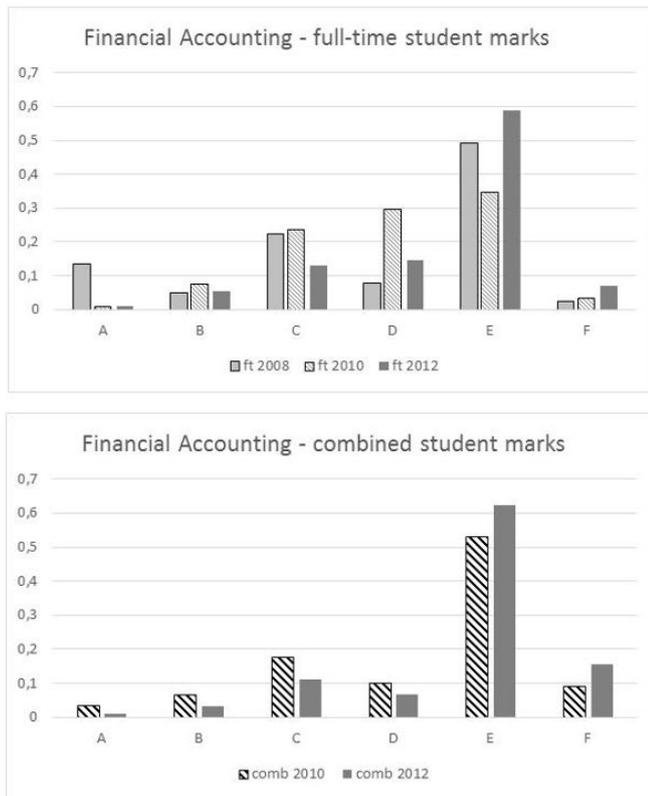

Figure 2: Financial Accounting – comparison of results (% of students with given mark), source: own calculations

We calculated also the average marks just to see the differences in this mean value for the selected subject during years and for the study fields and type of study. For the calculations mark "A" is equal to 1, "B" = 1.5, "C" = 2, "D" = 2.5, "E" = 3 and "F" = 4 (this is given by the rules of the college, these numbers are used for the average marks calculation). Based on the fact that we do not have continuous data set and the normality was not proven for all the subjects by the normality test, the calculated F-test

(showing the equality/inequality of the variances of two data sets) and two sample t-test (showing equality/inequality of the means) must be taken with circumspection only as complement to the Chi-square test results.

In the first part of our research we obtained Chi-square test results for the comparison of different years of study (for the economic subjects and both fields of study). They are 2008, 2010 and 2012 for full-time students and 2010 and 2012 for combined students. The e-learning materials started to be created in 2009 so some of the subjects could use them in 2010 and all subjects used it in 2012. According to the first hypothesis we have tested the independence of the results in different years (excluding "F from IS" described above). Tab. 20 shows all p-values for full-time students and for all subjects selected. As the significance level is equal to 0.05 (the critical value from the Chi-square distribution with 5 degrees of freedom is 11.07, nearly all values are higher) and all p-values are lower than 0.05 (Tab. 20, grey background) we reject the first null hypothesis (for all subjects except of BE in 2008) and we may say that there exist differences between the results of each subject in selected years. This result is in most cases supported by the F-test or t-test p-values that express the difference between variances or means. Only in 2008 for MIE and PF the results of F-test and t-test are different compared to Chi-square test but in these cases the normality of data was not proven (Fig. 3) and so the t-test should not be used and its results cannot be interpreted in the same way as in previous cases.

subject / years	p-value Chi-test (Chi--test value) (p-value t-test), (p-value F-test)		Average marks (full time students)		
	2008/2012	2010/2012	2008	2010	2012
BE	0.41660 (3.92)	0.00000 (24.07)	2.27765	2.93284	2.02477
	(0.89), (0.76)	(0.00), (0.00)			
MAE	0.00000 (22.83)	0.00021 (22.74)	2.50129	2.50283	2.28012
	(0.00), (0.43)	(0.00), (0.92)			
MGA	0.00036 (13.25)	0.00038 (41.42)	2.17991	2.25055	2.03364
	(0.00), (0.14)	(0.00), (0.01)			
MIE	0.02114 (78.33)	0.00000 (45.11)	2.85575	2.54139	2.85000
	(0.92), (0.09)	(0.00), (0.58)			
FIA	0.00000 (85.64)	0.0000 (151.37)	2.44709	2.75915	2.76332
	(0.00), (0.00)	(0.93), (0.17)			
PF	0.0000 (162.67)	0.0000 (371.04)	1.97543	2.4000	1.99662
	(0.55), (0.38)	(0.01), (0.75)			

Table 20: Dependence on the year (deg. of freedom=5; critical Chi-value=11.07) and average marks, source: own calculations
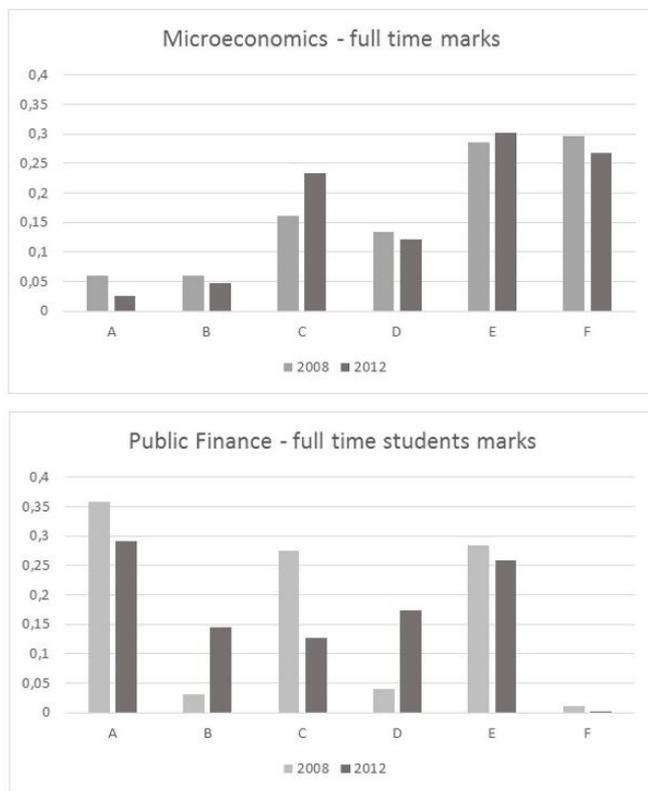
Figure 3: Microeconomics and Public Finance – comparison of relative frequencies of results (% of students with given mark), source: own calculations

Only for MAE and MGA we may say that the results improved from 2008 to 2012 (Table 20). In MIE the average mark is better in 2010 than in 2008 but in 2012 is again making worse. Those subjects are taught in first year of study and a lot of effort has been put into the e-learning materials preparation for the early students. So the results show that the e-learning materials in combination with face-to-face lessons probably helped the student to cope with these subjects. On the other hand, the average mark in FIA and PF increased. In FIA it might be caused by the higher level for passing (70 %) that makes the effect to pass with minimum points (and "E" is enough) for some students.

When we compare the results of the combined form of study (Tab. 21) we again reject the hypothesis about the independence of the marks between years (only *p*-values shown as it give us the same information as Chi-test values that are all higher than 11.07). All subjects have worse average marks in 2012 than in 2010 (except PF). Also the average marks differ (as *p*-value of t-test are lower than the significance level 0.05, only for MAE the *p*-value is a little bit higher than 0.05 but in this case the normality of data of the year 2012 was not proven so here we take into account the Chi-square test result). In this situation we cannot prove the positive impact on study result when using e-learning materials, maybe only for PF.

subject / years	p-value Chi-test (p-value t-test), (p-value F-test)	Average marks (comb. form students)	
	2010/2012	2010	2012
BE	0,00233 (0.00), (0.15)	2.65441	2.90097
MAE	0.00000 (0.06), (0.35)	2.25191	2.38393
MGA	0.00037 (0.00), (0.09)	1.97196	2.37222
MIE	0.00000 (0.00), (0.00)	2.23544	2.54592
FIA	0.00000 (0.00), (0.21)	2.69748	2.93889
PF	0.00000 (0.02), (0.09)	2.19231	1.85593

Table 21: Dependence on the year and average marks, source: own calculations

The second hypothesis was aimed at the independence of the results in both study fields. In Tab. 21 we see that only two *p*-values are lower than the significance level (grey background) and so in these cases we reject the hypothesis. In 2008 there were differences in marks between full-time students of TT and FM in MIE and FIA subjects. The average marks show that the students of FM were worse. It can be caused by the fact that in this year both subjects were taught each semester for different study field (the groups of students were from the same study field) but from 2010 the groups of students were mixed from both fields.

subject / years	p-value Chi-test (p-value t-test), (p-value F-test)		Average marks (full time students)			
	2008 TT/FM	2012 TT/FM	2008 TT	2008 FM	2012 TT	2012 FM
BE	0.07366 (0.00), (0,01)	0.32075 (0.82), (0.24)	2.59570	2.34507	2.75632	2.76506
MAE	0.52413 (0.09), (0,74)	0.16283 (0.03), (0.46)	2.44958	2.58389	2.20918	2.38235
MGA	0.10218 (0.01), (0.90)	0.26220 (0.30), (0.05)	2.10536	2.32095	2.00189	2.08383
MIE	0.00000 (0.29), (0,01)	0.08931 (0.38), (0.55)	2.81225	2.89808	2.88095	2.80201
FIA	0.00022 (0.00), (0.06)	0.91254 (0.99), (0.72)	2.30819	2.58599	2.76364	2.76301
PF	0.20556 (0.02), (0.85)	0.63099 (0.24), (0.83)	1.87393	2.07692	1.94748	2.04575

Table 22: Dependence on the study field (full time students, Travel and Tourism - TT, Finance and Management – FM) and average marks, source: own calculation

In 2008 we see again that some t-test and F-test results confirm the equality although the Chi-square tells the opposite. It is caused by non-normality of data - for example in BE there was nearly three times higher percentage of "F" marks of

FM students (18% compared to 6.7% of TT students) which influences the t-test results. We may conclude that the results of both study fields were the same before the e-learning usage and with the e-learning support. In MAE and MGA the average marks seems to be better in 2012 than in 2008.

The last hypothesis focuses on the independence between the results of full-time and combined forms of study. Only in one case (Tab. 23, PF) we do not reject the null hypothesis and we do not say that the study results in full-time and combined form differ. When we compare the average marks (Tab. 23) it might be interesting that the average for BE in 2010 is closer than the average for PF in 2010 where the null hypothesis was not rejected and so here the results are not dependent on the type of study. But if we compare the histograms (Fig. 4) it is clear that there are bigger differences in BE than in PF. On the other hand, nearly all average marks of combined students are worse than for full-time students. So we still see that it is harder to study in the combined form regardless of the e-learning materials.

Figure 4: Business Economy and Public Finance – comparison of results (% of students with given mark), source: own calculation

The next part of the paper aims at the mathematical and statistical subjects. These subjects were obligatory only for the students from the study field "Finance and Management". First hypothesis in this comparison was connected with the independence of the results in two compared years. Tab. 24 shows all *p*-values for full-time students and for all subjects (the significance level is still the same and equal to 0.05). The situation with the comparison of the years 2008 and 2012 is the same as in the previous analysis. We can say that there are differences in results for these two years. The difference is also evident in the average marks. Except of MAT2 all other subjects have worse average mark in 2012 than in 2008. The average mark for MAT2 is better in 2012 but it can be influenced by a fact that students knew the difficulty of the mathematic subjects and those who continue with the study (or repeat this subject) prepare themselves better for the exam.

subject / years	p-value Chi-test (p-value t-test), (p-value F-test)		Average marks			
	2010 ft/com	2012 ft/com	2010 ft	2010 com	2012 ft	2012 com
BE	0.00000 (0.06), (0.00)	0.00000 (0.00), (0.00)	2.36590	2.27765	2.67790	2.93284
MAE	0.00045 (0.00), (0.08)	0,00501 (0.08), (0.00)	2.42599	2.25191	2.33124	2.35603
MGA	0.00000 (0.16), (0.02)	0.00000 (0.32), (0.00)	2.26002	2.37222	2.04286	2.11756
MIE	0.00000 (0.00), (0.00)	0.00000 (0.00), (0.00)	2.57070	2.23553	2.84148	2.54592
FIA	0.00000 (0.32), (0.00)	0.04622 (0.00), (0.25)	2.51759	2.69748	2.76339	2.93889
PF	0.53245 (0.27), (0.16)	0.21175 (0.11), (0.75)	2.40000	2.19231	1.99662	1.85593

Table 23: Dependence on the type of study ((deg. of freedom=5; critical Chi-value=11.07) and average marks (full time, combined students), source: own calculations
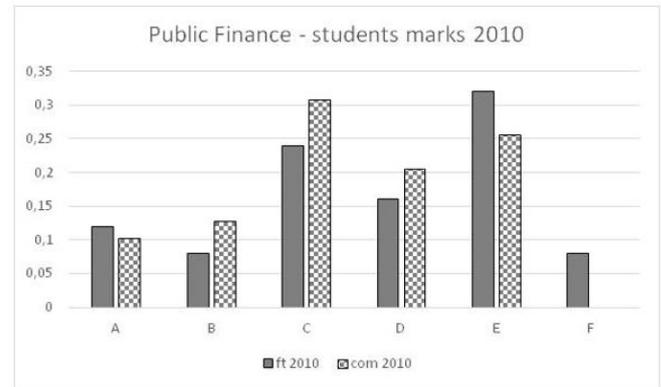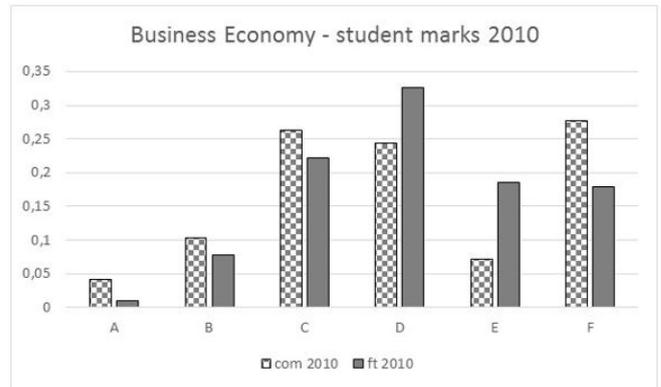
subject / years	p-value Chi-test (p-value t-test), (p-value F-test)		Average marks (full time students)		
	2008/2012	2010/2012	2008	2010	2012
MAT1	0.00000 (0.00), (0.04)	0.13656 (0.11), (0.15)	2.2245	2.5848	2.7143
MAT2	0.00001 (0.04), (0.03)	0.04929 (0.50), (0.95)	2.6375	2.5167	2.2805
MATE	0.00000 (0.05), (0.01)	0.01016 (0.02), (0.29)	2.2750	2.7039	2.4669
PS	0.00000 (0.02), (0.83)	0.80702 (0.85), (0.39)	2.2177	2.8528	2.8386
STM	0.00000 (0.00), (0.00)	0.00000 (0.00), (0.22)	2.1429	2.2826	2.5621

Table 24: Dependence on the year and average marks – mathematical and statistical subjects (full time students), source: own calculations

The comparison of 2010 and 2012 years gives different results than the comparison of 2008 and 2012 years. For MAT1 and PS the differences in marks in two years do not exist and we see (Fig. 5) that the results are analogical. During these years the e-learning materials were used, so in this sense it may cause the similarity of results. However, this is not true for the rest of the subjects. We may speculate that these 3 subjects (MAT2, MATE, STM) are the follow-ups of the MAT1 and PS and that is why the students that passed these two subjects have higher chance to pass the rest.
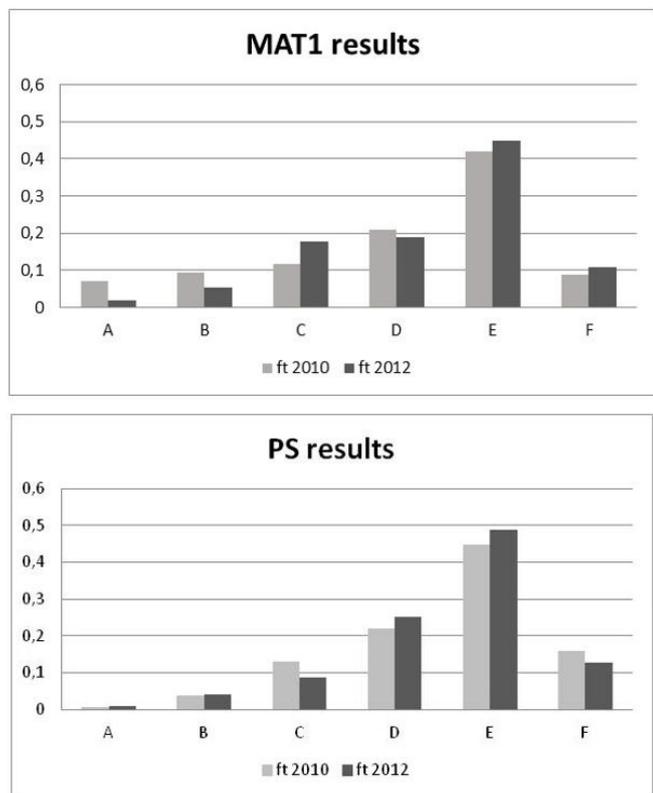
Figure 5: Mathematic 1 and Probability and Statistics – comparison of results of full-time students (% of students with given mark), source: own calculations

The situation in the combined form of study seems to be different (Tab. 25). According to the Chi-square *p*-values we can confirm the independence of the results of MAT1, PS and STM on the year of study although the t-test says the means differs. As the average marks are going to be worse (from 2010 to 2012) it is hard to say if e-learning helped the students or not. Maybe it reflects the fact that the number of students that can continue their study at the HEI has been falling since 2011 and so the quality of the students hired after 2011 is lower due to lowering requirements for points of the entrance examination at College of Polytechnics Jihlava. As a result, many students with worse mathematical skills are enrolled. PS (and MATE in 2012) seems to be the most complicated subject as the average marks exceeds 3 which means that a lot of students did not pass the subject for the first time. The analysis showed the independence on the year only for MAT2 and MATE but also here the average marks are getting worse.

| subject / years	p-value Chi-test (p-value t-test), (p-value F-test)	Average marks (comb. form students)	
	2010/2012	2010	2012
MAT1	0.06178 (0.03), (0.72)	2.4148	2.7388
MAT2	0.00690 (0.00), (0.09)	2.4080	2.7929
MATE	0.00267 (0.00), (0.18)	2.9609	3.4080
PS	0.37674 (0.02), (0.47)	3.3139	3.5122
STM	0.79461 (0.05), (0.93)	2.5588	2.6802

Table 25: Dependence on the year and average marks – mathematical and statistical subjects (combined form students), source: own calculation

The last analysis aims at the dependence or independence on the form of study in case of mathematical and statistical subjects. Tab. 26 shows the results – there is only one subject (MATE) in 2010 when the final marks are not dependent on the form of study although the average is worse for the combined form. For other subjects the frequencies of marks in the two fields of study differ.

subject / years	p-value Chi-test (p-value t-test), (p-value F-test)		Average marks			
	2010 ft/com	2012 ft/com	2010 ft	2010 com	2012 ft	2012 com
MAT1	0.03946 (0.14), (0.05)	0.00402 (0.84), (0.01)	2.5848	2.4148	2.7143	2.7388
MAT2	0.02731 (0.38), (0.02)	0.00000 (0.00), (0.91)	2.5167	2.4080	2.2805	2.7929
MATE	0.11845 (0.01), (0.12)	0.00000 (0.00), (0.04)	2.7039	2.9609	2.4669	3.4080
PS	0.00000 (0.00), (0.82)	0.00000 (0.00), (0.85)	2.8528	3.3139	2.8386	3.5122
STM	0.00226 (0.04), (0.11)	0.00000 (0.16), (0.00)	2.2826	2.5588	2.5621	2.6802

Table 26: Dependence on the type of study and average marks (full time, combined students) - mathematical and statistical subjects, source: own calculation

When we compare the histograms (Fig. 6) we see that in 2010 the full time students have more "A,B,C,D" marks than part-time students, but the shape of the histograms is nearly the same. The situation for full time students in 2012 is the best in "A,B" marks and also with "F" mark and so the average is the best here. The better results in 2012 might be influenced by the e-learning usage together with the face-to-face teaching. The worst situation in this subject is in 2012 for combined form – the highest percentage of "F" mark predicates about the difficultness of this subject for the self-study without face-to-face tuition (e-learning materials seems to be insufficient).
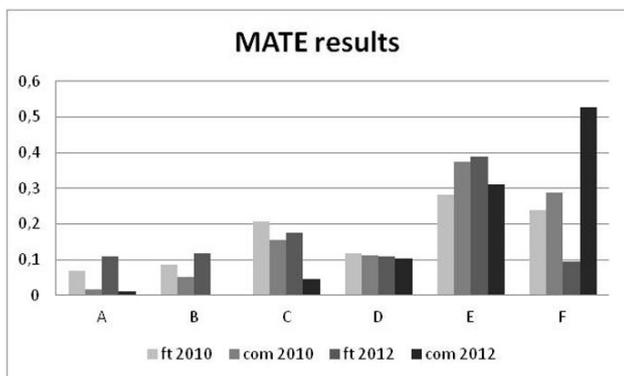
Figure 6: Mathematic for Economist – comparison of results of full-time and combined form students (% of students with given mark), source: own calculation

Discussion

The comparison of results for each subject shows that not all final marks are normally distributed. It is influenced by the conditions how to pass the given subject – and we see the tendency that the students usually do not try to obtain the best mark but try to pass. The similar tendency has been found out in the paper of Brozova, Rydval and Horakova (2014). Also Richardson, Morgan, and Woodley (1999) undertook a major study of approaches to studying in distance education study and founded similar result that approach was related to pass rates and final grades but not to course completion. So the "E" mark is very often grade especially when 70% in final exam to pass is needed. For the comparison of two years, two forms of study, two study fields or two subjects we use Chi-square test for independence. We may say that there exist differences between the results of each economic subject in selected years (similar as in Brozova, Rydval and Horakova, 2014). These differences can be caused by e-learning usage but also by more materials that students can use. Moreover, different students´ abilities to study can affect this (and willingness to study), but that is difficult to measure. As other similar studies (Brozova, Rydval and Horakova, 2014; Carnwell, 2000; Popelkova and Kovarova, 2013) we cannot confirm that the usage of e-learning material has an important positive impact on the study results although we proved the difference between the results but the average marks seemed to be rising more than falling down. May be it is caused by the lower quality of students due to lowering requirements for points of the entrance examination (but it is hard to test). Maybe the usage of the e-learning is counter-productive as some students thinks that it is not necessary to use any other materials (for example books) than e-learning materials. In the mathematical subjects the absence of the face-to-face teaching leads to worse results regardless of the e-learning materials (the same findings as Brozova, Rydval and Horakova, 2014) and we also proved that the results of combined form of study are different and worse (especially in 2012 with the possibility of the e-learning materials usage) compared with the full-time study form results from all mathematical and statistical subjects. One "positive" aspect taken from the results is that it is better to mix students from different fields of study in the full time study process to get better marks. We can also make for a view that if the students passed the subjects in the first year of study they have higher chance to pass the rest subjects as the first year of study can separate those students with higher and lower ability to study at HEI.

Conclusion

The comparison of the results between different years of study – before e-learning usage and after it – showed that the differences between students' final marks both in full-time and combined form of study exist. We have proved the differences between the results in 2008, 2010 and 2012 in the full-time form of study (except of the subjects MAT1 and PS) and also the difference in 2010 and 2012 in economic subjects for the combined form. But it is not possible to say that these differences are caused only by using of the e-learning materials as in some subjects the results are worse than before (especially in mathematical and statistical subjects). The difference between the students of the two study fields was not proved. We only confirmed that the results between the study forms (full-time and combined) differ (except of the subject PF) and students of the combined form had usually worse average marks. If this is the reason of few materials in e-learning, no effort to study more than from e-learning, students' ability to study, fewer time or lack of face-to-face lessons it can be a part of further research. As the other authors (mentioned in the introduction and discussion) reached the same results such as very small or any influence of the e-learning onto the evaluation we may conclude that the e-learning is a useful tool for students. However, it cannot be considered as the only tool how to give materials to students and how to study.

Acknowledgements

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