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EDITORIAL

Journal on Efficiency and Responsibility in Education and Science (ERIES Journal) has gone through another exciting year. We are glad that our readers have stayed loyal to ERIES Journal and we have received many interesting articles for publications. We already are excited about the upcoming year, where ERIES Journal will celebrate its first decade. To celebrate the first decade of ERIES Journal, we are preparing several innovations that, we hope, will be appreciated by all our readers and reviewers.

In this last issue of the year 2016 (Vol. 9, no. 4) we have variety of articles from the Mendel University in Brno, University of Finance and Administration in Prague, and University of Economics in Prague. As in the previous issue, we are glad that ERIES Journal constantly attracts researchers, academics and authors from various institutions.

First article from authors Kučerová, Formánková and Prísažná from Mendel University in Brno present results of a qualitative survey of corporate social responsibility (CSR) in the tertiary education sector. For the assessment of High Education Institutions' engagement in CSR activities, the authors used seven key areas covered by ISO 26 000 standard. The survey was performed through controlled interviews with competent representatives of Faculties of Economics at three public universities in the Czech Republic. The results show that CSR does exist in the tertiary education sector in the Czech Republic. However, CSR is not always implemented in a targeted manner of the school strategies, appropriately communicated and reported.

Second article presented by Jiří Duda from Mendel University in Brno provides results of research on students' requirements, members of the Generation Y, in providing employee benefits. The research was conducted during the period between 2002-2014 among master students of Mendel University in Brno. The article examines whether the gender of the respondent influences the set of desired employee benefits. Results show that women mostly prefer Coverage of language courses, Children's nurseries and kindergartens, Contribution for Christmas (Annual bonus), and Contribution to recreation. On the other hand, men mostly prefer benefits such as Share of profits, Provision of employee stocks, and Use of company car for private reasons.

Third article from Eva Ulrychová from University of Finance and Administration in Prague analyses students' knowledge of basic mathematics based on test results from different courses at the University of Economics in Prague and at the University of Finance and Administration in Prague. For this purpose, the author disseminated mid-term exam with a theoretical part to three different groups of students who did not expect the theoretical part in the exam, and who expected the theoretical part in the exam. All students had to formulate definitions of linear combination of vectors, linear dependence of vectors, rank of a matrix, invertible matrix, and matrix inversion. Regardless a group, the most common errors have the same character. In general, in most cases students were not able to formulate terms in generic way, struggled with generalized notation, ignored quantification, did not make any differences between definitions and theorems.

Last article from Jindřich Klůfa from University of Economics in Prague provides an analysis of the differences in number of points in mathematics test between test variants, which were used in the entrance examinations at the Faculty of Business Administration at University of Economics in Prague in 2015. The aim of the article was to study dependence between results of entrance examinations in mathematics and test variants. For this purpose, the author analysed data from 1,514 entrance examinations. Results show that differences between average number of points in mathematics in test variants are statistically significant. Therefore, an increase in the homogeneity of test variants would be very useful.

We hope that all our readers will find this last issue of the year 2016 interesting, and we also hope that the ERIES Journal will contribute to the field of efficiency and responsibility in education as it has contributed so far. With the end of the year 2016 we would like to thank to all the authors and reviewers who contributed in increasing the ERIES Journal quality.

We wish you all the best for the year 2017.

Sincerly,

Martin Flégl

Executive Editor

ERIES Journal

SOCIAL RESPONSIBILITY IN HIGH EDUCATION INSTITUTIONS: EVIDENCE FROM ECONOMIC FACULTIES IN CZECH REPUBLIC

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Highlights

- *Analyzed HEIs in the Czech Republic are involved in CSR activities even though the CSR concept is not always part of their strategy.*
- *HEIs, who have their CSR concept integrated in their strategic documents, receive higher rating in most key areas of ISO 26000 standard.*
- *Engagement of HEIs in corporate social responsibility areas follows from the approach of the faculty and university management to social responsibility as such.*

Abstract

The presented paper shows results of a qualitative survey of corporate social responsibility (CSR) in the tertiary education sector. Economically oriented faculties of public universities in the Czech Republic were selected. For the assessment of High Education Institutions´ engagement in CSR activities seven key areas covered by ISO 26 000 standard were used. Analyzed High Education Institutions in the Czech Republic are engaged in many CSR activities but these activities are often untargeted and representing by-products of other activities. The main drawbacks of all assessed faculties in the key area five – "Environment" were discovered The results for the first key area – "Organisational governance" show that integration of the CSR concept in High Education Institutions strategy substantially defines the level of their overall engagement in corporate socially responsible activities.

Keywords

Economic faculty, engagement, ISO 26 000, public university, social responsibility, strategy

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Introduction

Corporate social responsibility (CSR) has become a common and significant part of business in many countries. CSR brings a competitive edge to the businesses in the form of higher motivation of employees as stated for example by Milton de Sousa Filho et al. (2010), also improving image, reputation, and improving customer loyalty (Aya Pastrana and Sriramesh, 2014). According to Flammer (2013), CSR can bring better access of the business to finance, predicts innovation climate in the firm (Ubius and Alas, 2012) and have a positive impact on the whole business performance (Yusoff, Mohamad and Darus, 2013).

The huge boom of the CSR concept in the profit sector increases importance of CSR teaching. Future managers need to be equipped with competences for introduction and management of the corporate social responsibility concept. According to Vazquez, Lanero, Licandro (2013), the prioritised introduction of CSR teaching is currently supported by three reasons. The first reason is the CSR concept development in the world of business, increasing the demand for professionals qualified for responsible governance. The second reason is that CSR has been increasingly popular also outside the private sphere. CSR has been a frequently discussed theme at governmental meetings, supra-national organisations, social organisations and other institutions. This sense, the idea that sustainable development largely depends on the responsible behaviour of both organizations and citizens is more and more consolidated. And thirdly, all of this have led universities to ask themselves about their own responsibility thus gaining awareness of their role in the education and training of professionals provided with the competences and values needed for sustainable development. Universities are well aware of the need of education in this very area. Many business schools worldwide have consequently integrated CSR and sustainability-related topics into their management programmes (Moratis, 2014). As shown by Giacalone and Thompson (2006), very important is how students will be educated in the area of business ethics and corporate social responsibility. The need of established ethical frameworks and procedures in business circles has never been bigger (Jorge and Peña, 2014). This is also documented by research results of Ahmad (2012) who says that students must be well-informed and exposed to the benefits of CSR initiatives and then their levels of participation in CSR activities is high. The universities are still superior at satisfying public demand for quality education (Othman and Othman, 2014) and provide students with the maximum breadth and depth of the theoretical knowledge (Stojanová and Tomšík, 2014).

Corporate social responsibility teaching is however only one side of the coin. Universities themselves should be an example for their students and for businesses, behave responsibly and include the CSR concept in their activities. In addition, corporate social responsibility can become a competitive advantage for the university or higher educational institution itself. Involvement of universities in CSR activities is however a new and still developing phenomenon. The concept of CSR and its principles are yet to be proven in the higher education industry (Othman and Othman, 2014).

This is also closely connected to the role of universities. The educational and research role has recently been extended with the social role. While some universities and higher education

institutions only understand this role as a link to the business sphere and business supporting activities, others take it as an active social role very closely connected with socially responsible behaviour to all their stakeholders. Yokoyama (2006) speaks about business university performing activities such as establishment of businesses, advisory activities, community service and scholarship provision.

Lehmann et al (2009), on the other hand, emphasizes the fact that universities are here to develop human and intellectual capital, produce simultaneous effect on the natural and production capital as well as institutional capital of the society and are to be involved in network, cooperation and trust building in the society which is becoming more and more dependent on these values.

This paper includes an analysis of involvement of the High Education Institutions (HEIs) – three faculties of economics of public universities in the Czech Republic – in corporate social responsibility activities. The main prerequisite is making CSR part of strategic management of the university without which CSR development at the university can never be sufficient.

Partial results of the research were presented at the 6th International Conference on Management - ICOM 2016 (Formánková, Kučerová, Prísažná, 2016). Paper from this conference includes the analysis and the results of only one faculty and its participation in the social responsibility concept. This paper is the extended version and contains an analysis of three economic faculties of public universities, comparison of results and their approach and application of CSR principles in their activities, conclusions and recommendations resulting from this comparison.

The research efforts are to bring the knowledge of the current situation in the area of social responsibility of universities and thereby contribute to its development.

The paper is divided into three sections - the results of faculties' engagement in CSR activities; their comparison; and discussion of findings in relation to behaviour of each faculty in the assessed areas.

Materials and Methods

The subjects of the present research have been faculties of economics of three public universities of the Czech Republic - the Faculty of Business and Economics (FBE), Mendel University in Brno, the Faculty of Economics and Administration (FEA), Masaryk University in Brno, and the Faculty of Business and Management (FBM), Brno University of Technology.

The research was conceived as qualitative and performed through controlled interviews with competent representatives of the faculties and management of the universities. The controlled interviews followed from a questionnaire pursuant to the international ISO 26 000 (ISO, 2013) standard, adapted for public universities with economic orientation. There were 7 key evaluated areas and further sub-areas pursuant to the applied standard (ISO, 2013):

6.2 Organizational governance - Accountability, transparency, ethical conduct, consideration of stakeholders' interests and legal compliance (KO-1)
6.3 Human rights (KO-2)
6.4 Labour practices (KO-3)
6.5 Environment (KO-4)
6.6 Governance based on rules – fair operating practices (KO-5)
6.7 Consumer issues (KO-6)
6.8 Community involvement and development (KO-7)

The controlled interviews were primarily focused on corporate social responsibility of the evaluated faculties in their approach to students, employees, the community, the environment and interest groups. The approach was assessed with regard of involvement of the individual faculties in CSR activities as well as CSR teaching.

As some CSR activities are performed and managed on the university level faculty activities could not always be clearly distinguished from university activities in the CSR area. Where the faculties were involved in or affected by university-wide CSR activities there these activities were included in the assessment.

The results obtained from the controlled interviews were combined with information from strategic documents of the assessed faculties and from other resources. These included long-term projects of the faculties and the universities for the period 2016-2020, and their updated versions for 2016, rectors´ decrees and guidelines, disciplinary rules and annual reports on faculty and university activities and data and reports published in the faculty and university web sites, faculty articles of association, ethical codes and other documents.

The qualitative research results were assessed by the methodology used for analysis of socially responsible conduct at the Pedagogical Faculty of Catholic University at Ružomberk using ISO 26 000 standard (Madzík, P. et al., 2015). The methodology fully respects the main principles and recommendations of the standard. ISO 26 000 standard is only recommending and self-evaluating in nature using perception and evaluation of the project teams.

Quantification and assessment of faculty activities in the individual key areas uses numerical scale from 1 to 3 (1, 2, 3). The scale is based on a similar method by Černohorská and Putnová (2012). For simplification the scale was modified from 5 to 3 points, where 1 = MIN and 3 = MAX, meaning:

- 1 – Involvement of the faculty in the given activity is negligible and its corporate social responsibility is minimal,
- 2 – Involvement of the faculty in the given activities is small to medium and its corporate social responsibility is average,
- 3 – The activity is significant for the faculty, paid much attention to and therefore the faculty corporate socially responsible engagement is maximal.

The resulting assessment of involvement of the evaluated faculties in the individual key areas is calculated as the ratio of the total intensity of the individual key areas (KO-1 - KO-7) and the total number of sub-areas within every key area.

The present paper shows particular results obtained by controlled interviews with competent representatives of the individual assessed faculties in the individual key areas of KO 1 – KO 7 in comparison of the individual faculties with regard to their CSR involvement.

Results

Faculty of Business and Economics (FBE), Mendel University in Brno

Key area KO-1 - Organizational governance

FBE achieved the score of 1.88 (see Table 1). FBE currently does not have CSR principles incorporated in the faculty strategy and management – they are no part of the long-term strategy for 2016–2020, i.e. there is not CSR strategy at FBE yet. The management of FBE does not yet consider corporate social responsibility substantially beneficial for the faculty. FBE does not create CSR report and has not implemented special CSR standards in its activities. However, even though the conduct of FBE is not targeted, the faculty subconsciously does many socially responsible activities. FBE complies with principles of ethical conduct and tries to consider stakeholders´ interests. FBE complies with the law of the Czech Republic.

Key area KO-2 - Human rights

FBE rating is above-average (2.26 – see Table 1). However, activities in this area pursuant to ISO 26000 standard closely correspond to compliance with Czech law in the human rights area. Hence such a high rating. FBE principally does not engage in activities outside the scope of its legal commitments.

Key area KO-3 - Labour practices

FBE achieved 1.78 score (see Table 1) FBE tries to recruit talents into its staff although not using any exactly defined talent management. FBE employs handicapped persons and flexibly reacts to their needs. These employees are provided with clearly suitable working conditions, some of them even exceeding the framework of legislative duties. FBE tries to keep maximum level of physical as well as mental wellbeing of its employees – provides theatre tickets, organises teambuilding activities, the staff as well as the students can visit the arboretum free of charge etc.

The persisting issues in this area substantially include cross-faculty communication and employee feedback, which is not provided at FBE at all.

Key area KO-4 - The environment

The lowest rating was obtained by FBE here (1.36 – see Table 1). FBE is engaged in this area in just basic activities such as waste sorting, paper and toner recycling, two-pole toilet flushing for water saving or purchase of recycled paper. However, FBE is as a rule not engaged in environment and ecosystem protection and renewal by its services and activities, taking no steps towards education of its staff on responsible use of natural resources and development of their environmental awareness and responsibility. The environmental criterion is only considered in public tenders in some and not all cases.

Key area KO- 5 - Fair operating practices

FBE was evaluated with the score of 2.06 (see Table 1). FBE clearly complies with all conditions of fair competition by all its activities, providing sufficient information about all courses and subjects available for study in the national and world languages. In the area of plagiarism, the university has a system in operation which is part of the university information system. However, there are no special programmes or bodies for corruption prevention, although the faculty has not detected any corruption case in its to-date history. FBE does not monitor its partners for cooperation with regard to their corporate social responsibility. And the CSR criterion is not included in public tenders.

Key area KO-6 - Consumer issues

The second highest rating was obtained by FBE in this key area (2.20 – see Table 1). FBE performs fair marketing, providing its stakeholders with particular, complete and unbiased information about its activities. Students are provided with "welfare" through student clubs and events, and an active Student Union. To support mental health of its students FBE provides psychological advisory service available at the ICV (Institute of Lifelong Learning). FBE also provides additional education to undergraduate and graduate students. Courses in excess of compulsory study subjects are available via ICV free of charge or discounted for students. FBE increasingly considers individual needs of students. Requirements of students with specific needs are found out by the study department before the course commencement by the student, in the context of the entrance examination and via ICV.

FBE also pays sufficient attention to interest group identification, trying to harmonise their interests with faculty interests. Student interests are mainly found out through evaluations. Information obtained in this way is discussed and considered by competent persons (pro-dean, teacher, guarantor etc.), who can react to them. Unfortunately, there is not feedback to feedback and so the students do not know whether and how their suggestions are addressed.

Insufficient activity has been detected in the sub-area of Sustainable Consumption. FBE is not explicitly engaged in resource wasting prevention and environment damage through consumer activities, does not keep statistics of annual resource saving and activities in the area of environment damage prevention. FBE also implements no systematic steps towards change of the present or future student behavioural patterns in the area of environment protection. FBE teaches subjects concerning CSR and ethics. However, these subjects are only compulsory for a single specialisation. For the other specialisations they are optional and thus not accessible to everybody.

Key area KO-7 - Community involvement and development

FBE achieved 1.83 score (see Table 1). Even though FBE has no special programmes for community engagement and no reserved funds for this area it still actively participates in educational and cultural community programmes. Some activities are implemented on the faculty level, others are organised by the Student Union, yet others on the university level and a few even only within the individual subjects taught.

	Organizational governance (KO -1)	Human rights (KO-2)	Labour practices (KO-3)	The environment (KO-4)	Fair operating practices (KO-5)	Consumer issues (KO-6)	Community involvement and development (KO-7)
Total intensity of the influence	32	75	57	15	33	77	44
Number of issues	17	31	32	11	16	35	24
Average intensity of involvement of the faculty	1.88	2.26	1.78	1.36	2.06	2.20	1.83

Table 1: Evaluation of the FBE MENDELU in Brno in key areas (source: own research)

Faculty of Business and Management (FBM), University of Technology Brno

Key area KO-1 - Organizational governance

In the first key area (KO-1) FBM was rated 1.71 (see Table 2). CSR principles in the governance area are included in the ethical code of FBM and the Brno University of Technology as a whole. The ethical code is also a tool for ethical behaviour monitoring. It exists in the written format and is also published on the web site of FBM and university. FBM management considers responsible conduct an asset for the faculty and compliance with principles of ethics a significant part of the process of education, whether in the context of the courses or by following models in the surroundings. FBM evaluates ethical conduct of all academic staff, taking preventive measures and sanctions to prevent or in the case of violations. The faculty considers requirements of interest groups and takes measures to meet them and increase their satisfaction.

FBM does not have any established CSR strategy, though, no strategic documents where CSR would be included. FBM does not spread knowledge of socially responsible conduct among its stakeholders, employees are not involved in decision making about social responsibility issues. FBM is not member of any CSR platform, does not publish CSR reports, does not have social or ethical audits performed and has no body supervising corporate social responsibility compliance and ethical behaviour. CSR issues are only addressed by certain employees, either in their free time or in the context of their professional orientation.

Key area KO-2 - Human Rights

FBM score in second key area (KO-2) was 2.26 (see Table 2). FBM asserts human rights protection by its employees, students and interest groups. Compliance is monitored through a trust letterbox, a disciplinary committee, teaching evaluations and the academic senate.

FBM has so far met with no human rights violation within its walls. FBM has established procedures of action in risk situations. These procedures, however, follow from the university act, valid legislation of the Czech Republic, FBM and BUT statues and ethical codes.

FBM employs people without any discrimination, not monitoring their numbers and percentages, though. At present one third of managerial positions are held by women. This condition is not specifically monitored, though. Positions are also held by other ethnic and racial groups but this condition is not monitored either. Also students are admitted regardless their physical handicaps or race. Evaluation rules are clear and do not involve any discrimination. In the cases of collective bargaining there are trade unions as employee representatives. FBM respects the right of association, collective bargaining, exclusion of all forms of forced and child labour, but does not examine its suppliers from this point of view. Most FBM activities in this area are required by the law of the Czech Republic and are not in excess of compulsory legislative requirements.

Key area KO-3 - Labour practices

The second lowest rating was received by FBM in the third key area (KO-3), 1.66 (see Table 2). FBM performs human resource planning and applies defined procedures of HR management, based on organisational structure. The requirements are based on the needs of the individual institutes and a strategic council deals with this on the faculty level. However, FBM does not clearly plan human resources to prevent unnecessary limited period employments. Talent management is not established at FBM. FBM tries to keep physical, mental and social welfare of its staff and human resource development. Employees as well as students can use the Centre of Sports Activities (CESA) and training course of the Lifelong Education Institute.

FBM has no established outplacement. Overtime work is not extra paid. FBM has no authorised representative for social dialogue. Employment relationships are not monitored, various interest groups are formed and there is rivalry between institutes. Steps are taken in the context of labour relationship improvement but individually by single institutes and departments. FBM employees enjoy adequate working conditions, FBM takes care of their safety and health, but only within the scope of compulsory legislative requirements.

Key area KO-4 – The environment

The lowest score of 1.18 (see Table 2) was achieved by FBM in key area KO-4. In this area FBM is only engaged in waste recycling and purchase of energy-saving devices. No other activities in the area of environment protection are implemented, there is no environment protection budget and this criterion is not considered in public tenders either.

Key area KO-5 - Fair operating practices

FBM was evaluated with 2.00 score here (see Table 2). FBM complies with all defined conditions of fair competition by all its activities. FBM tries to provide sufficient information about the offered courses and subjects in Czech and in English. This information is shown on the faculty web site or in promotional materials. FBM conduct is transparent and all options are weighed before particular project selection. Subcontractors are not reviewed with regard to their corporate social responsibility and CSR criterion is not one of the criteria applied to public tenders. Other criteria are considered, which FBM deems not relevant, such as price, quality, lead times etc. FBM has no established anti-corruption programme but there has been no case of corruption among its staff so far. FBM does not publish CSR reports and its CSR activities on its web site. FBM respects ownership rights, especially copyright. Compliance is defined by law and the plagiarism control system is the tool.

Key area KO-6 - Consumer issues

The rating of FBM was 2.09 (see Table 2). FBM tries to harmonise interest of students with interest of the faculty. Information about student interests and needs is collected through teaching evaluations and information collection by the study department, and further through periodic questionnaire inquiries providing feedback for student service improvement. FBM monitors numbers of graduates, their success on the job market and graduate feedback at regular meetings. FBM also takes sufficient care of students in the OHS area. There is a faculty doctor available to them. FBM has introduced a new access system to the faculty premises and a new non-stop security guard service.

Social scholarships are provided to students from socially weak families. Students can also be granted bonuses for extraordinary achievement if the defined conditions are fulfilled. Additional education of undergraduates and graduates is provided through various courses, training sessions, certifications and optional subjects in cooperation with ICV.

CSR-focused subjects taught at FBM include: Ethics in business, Corporate social responsibility and ethics in business, Social contact and rhetoric.

FBM uses fair marketing and there are special university-wide (BUT) regulations for marketing and publicity. There are, however, no emergency procedures to address issues in this area and there is no body supervising the marketing practices used.

Key area KO-7 - Community involvement and development

The last key area (KO-7) was scored for FBM with 1.75 (see Table 2). FBM engages in community involvement by some of its activities but without any comprehensive programme in this area. The activities include joint projects of faculties, conferences, cooperation with NGO and the private sector in the context of teaching. FBM is engaged in collection of PET bottle caps, chemist´s and alimentary products and in support for the handicapped. FBM contributed to educational and cultural programmes within the community, for example by means of football and ice-hockey tournaments between universities, and offers Third Age University for seniors. However, in the context of investment decisions, purchases of products and services FBM does not consider new job opportunity creation and does not prefer local suppliers in public tendering processes. FBM does not make significant investments into infrastructure or other programmes for improvement of the social aspect of community life. Where the faculty does take part in these activities it is only singular and one-off actions that do not repeat and are not planned for this purpose.

	Organizational governance (KO-1)	Human rights (KO-2)	Labour practices (KO-3)	The environment (KO-4)	Fair operating practices (KO-5)	Consumer issues (KO-6)	Community involvement and development (KO-7)
Total intensity of the influence	29	70	53	13	32	73	42
Number of issues	17	31	32	11	16	35	24
Average intensity of involvement of the faculty	1.71	2.26	1.66	1.18	2.00	2.09	1.75

Table 2: Evaluation of the FBM University of Technology Brno in key areas (source: own research)

Faculty of Economics and Administration (FEA), Masaryk University in Brno,

Key area KO-1 - Organizational governance

The score of FEA in the first key area (KO-1) is high, 2.47 (see Table 3). FEA considers itself a public educational institution, co-creator of certain values and standards which should also become part of its existence. In this sense FEA tries to approach all its activities. A number of them originate on the university level. FEA as well as Masaryk University as a whole realize their social responsibility very well. That is also manifested by the governance method. The FEA management consider socially responsible conduct very beneficial. CSR strategy is formally included in the long-term plan of the faculty, based on the long-term plan of the university. On the university level there is a work committee of the senate focusing on CSR issues and bringing in new proposals based on suggestions of representatives of individual faculties. Also the material plan, submitted for approval to the academic senate together with the budget, defines material priorities, with a chapter on public relations, including socially responsible activities.

The long-term plan of FEA includes a specific strategic priority no 4 entitled Active Social Role. There FEA defines its strategic objectives in the area of social responsibility. FEA supports involvement of the whole faculty and its staff in socially responsible activities, creating an inspiring environment with the aim to support common value of the faculty and the subject, to create conditions of inclusion of disadvantaged students, to develop institutional partnerships with public and private sector institutions and to promote public discussion on society-wise themes connected with the professional profile of the faculty. FEA is also institutional member of the CSR involved parties platform. Principles of ethical behaviour are formally defined in the written ethical code of employees of Masaryk University in Brno. They mainly concern education, research, assessment and expert activities. The ethical code however also defines principles of teamwork, project planning, result publication, principles of collegial conduct, loyal relationship to the university and the public etc.

FEA considers requirements of stakeholders, as also follows from the faculty orientation and interest. FEA has developed a broad system of corporate partnerships. There are several FEA platforms established for the very reason of maintenance of contacts with other institutions and finding about their interests. FEA annually meets with its external partners to find about their requirements. FEA complies with the law of the Czech Republic, having all of its activities controlled by a lawyer. FEA implements no activity without legal assessment. However, FEA does not prepare CSR reports usable for periodic assessment and publication.

Key area KO-2- Human Rights

FEA score was 2.29 (see Table 3). FEA has so far addressed no human rights violation case, taking care of compliance with the law of the Czech Republic in this area. FEA carefully observes guidelines and standards of the faculty based on non-discrimination principle. All FEA activities follow this principle although it is not formally defined. FEA employs people without any gender or nationality based discrimination. FEA does not monitor numbers of students and employees from other ethnic groups. There is a university-wide "Teiresiás" centre helping students with all sorts of handicaps successfully complete their studies.

Key area KO-3 - Labour practices

The key area KO-3 was scored with 2.22 (see Table3). FEA plans human resources, has defined procedures for human resource management. Employee recruitment is planned with the aim to prevent unnecessary temporary employments. However, FEA has not yet introduced any talent management practice. Employment relationships are considered very good and there are few cases of conflicts of interests of the faculty and its employees. FEA grants various awards to its academic staff, for example for the best professional book, for the best scientific article, Dean´s prize for young scholars below 35 etc. Rector´s prize is granted in categories like significant extraordinary result in international grant competitions, excellent teaching results, long-term excellent research results, active development of civic society etc. FEA employs handicapped employees. FEA takes

care of further professional development of its staff. Long-term efforts in excess of compulsory legal requirements include the academic club on the premises of FEA. It is a multifunctional area accessible to all FEA employees, for example with a fully equipped kitchenette. Employees further receive a meal ticket contribution and can choose between meal tickets and subsidised school canteen meals. FEA provides many other employee benefits, such as vouchers for cultural and educational activities, organisation of tourist trips etc. Employees can take days off for overtime work.

Communication of FEA management with employees is assured through a periodic inquiry where FEA employees can express their opinions.

Key area KO-4 – The environment

The lowest rating was received by FEA in this key area (KO-4) – 1.73 (see Table 3). FEA sorts waste and recycles plastics, paper and batteries. FEA tries to minimise document printing. FEA considers the environment in public tendering processes, with maximum effort at energy, water and material saving, for example by using saving water taps. FEA tries to be most sparing and economical in the area of water, soil and fuel management. FEA is member of a joint venture dealing in revitalisation of trees in the surroundings.

However, there is no official environmental guideline at FEA. There is no targeted course or project focused on change of employee attitude to the environment and their more environment-friendly behaviour at FEA. However, FEA tries to demonstrate model behaviour in this area and assumes the employee to follow its example in their everyday life.

Key area KO-5 - Fair operating practices

This key area (KO-5) was evaluated with 2.38 (see Table 3). FEA observes conditions of fair competition in all its activities, has simple and clearly defined rules in areas where fair governance might be violated, and respects ownership rights. FEA provides sufficient information about the offered courses and subjects in the national and world languages. The information is provided via standard communication channels – printed brochures, faculty web site, social networks. FEA is interested in corporate social responsibility of its potential partners and considers with aspect when selecting them. At the same time FEA promotes its social responsibility in its partners´ organisations. In public tenders FEA considers the CSR criterion.

Although FEA does not create and publish any CSR report, CSR activities can be found on its web site.

Key area KO-6 - Consumer issues

In this key area (KO-6) the rating of FEA was the highest of all 2.57 (see Table 3). FEA operates a public relations and marketing department and has a pro-dean for public relations. Marketing is centralised at FEA, with clearly defined rules. In the healthcare area FEA pays sufficient attention to student requirements, trying to harmonise their requirements with faculty interests. Faculty students can use a gym and there is psychological advisory service available on the university level.

FEA takes care of student welfare through support for activities of student unions active at FEA. Foreign students can use a tutorial programme. Handicapped students are supported by the "Teiresiás" programme. FEA also organises activities focused on change of current values and behavioural patterns of students and employees. FEA tries to influence their responsible use of natural resources. In the context of social responsibility teaching there is a CSR subject taught at FEA in English. CSR is taught in the Czech language in the context of marketing courses. Communication aimed at finding out student interests is implemented through a periodic inquiry organised by the university. Employees are liable to work with the inquiries filled out by the students and respond to their comments and suggestions.

This liability follows from the respective FEA guideline.

The university offers its students to take optional subjects at any other faculty. To that end the timetable and schedule of the academic year are unified across the university so that the students can enrol for the optional subjects at other faculties as they like and successfully attend and pass them. FEA is involved in the project entitled "To work by bike", extended for its own purposes with "To school by bike".

FEA monitors numbers of successful graduates, their success on the job market and the time to their first job. FEA has established a data protection policy and programmes for support for students from socially weak families. The faculty further organizes various summer schools, foreign scholarships etc.

Key area KO-7 - Community involvement and development

The score of 2.33 (see Table 3) was obtained by FEA in this key area (KO-7). FEA cooperates with NGO, the private sector, the city, the region, and the Economic Chamber. FEA is involved in many programmes for the community – such as financial literacy in cooperation with the City Foundation aimed at improvement of financial literacy of the youth. Under the auspices of the university the faculty has implemented a project called Juniversity including lectures for children at the age of 9 – 14 years. FEA also joined the project of ESS entitled Living Together. The project focused in provision of accommodation for children leaving children´s homes.

FEA is involved in community education programmes for all age categories, also thanks to the Third Age University. Many activities in this area are implemented in the context of lifelong education on the university level.

FEA does many things creating new job opportunities, which must make sense by themselves, not only as sources of job opportunities. The goal is not to provide money to people but to teach them to earn the money for their projects.

FEA tries to operate the faculty as an open place where people can meet.

Comparison of involvement of all three faculties in corporate social responsibility activities in the individual key areas pursuant to ISO 26 000 standard is shown in Figure 1.

	Organizational governance (KO-1)	Human rights (KO-2)	Labour practices (KO-3)	The environment (KO-4)	Fair operating practices (KO-5)	Consumer issues (KO-6)	Community involvement and development (KO-7)
Total intensity of the influence	42	71	71	19	38	90	56
Number of issues	17	31	32	11	16	35	24
Average intensity of involvement of the faculty	2.47	2.29	2.22	1.73	2.38	2.57	2.33

Table 3: Evaluation of the FEA Masaryk University in Brno in key areas (source: own research)

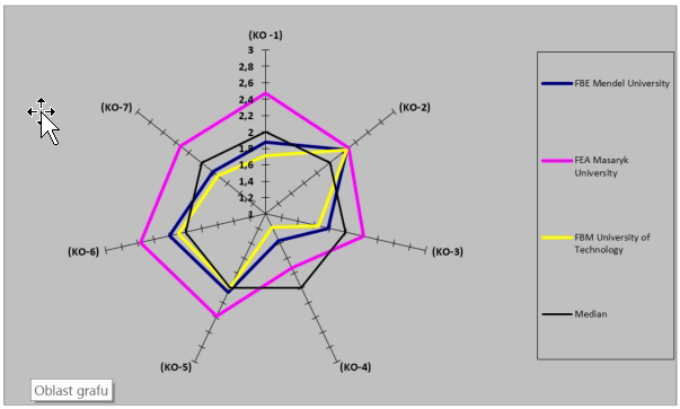

Figure 1: The average intensity of involvement of evaluated faculties in key areas (source: own research)

Discussion

Comparison of CSR survey results for individual faculties shows fundamental differences between FEA of Masaryk University and the other two faculties, FBM of University of Technology and FBE of Mendel University, in all assessed key areas except for KO-2 Human rights (see Figure 1). FEA exceeded the median value in all key aspects pursuant to ISO 26 000 except for KO-4 Environment.

The main difference between the faculties lies in the fact that FEA has the CSR concept included in its strategy. It is the only faculty of the three analysed with a targeted corporate social responsibility approach and formulated CSR principles, with emphasis on socially responsible behaviour in all areas of its activity. Corporate social responsibility is part of long-term orientation of both Masaryk University and FEA. Faculty management considers CSR beneficial for the faculty, there is a working committee for CSR on the university level and the CSR concept is part of the material plan of the university. Neither of the other two assessed faculties has the CSR concept CSR built into their activities in any similar way.

All three faculties received above-average scores in key area ***KO-2 Human rights***, FEA 2.29, FBM and FBE 2.26. This was despite the fact that most activities implemented by the faculties in this key area KO-2 only meet compulsory legislative requirements with minimum engagement in excess of the legislative requirements. Although Kuldová (2012) states that organisations should also take steps beyond the compulsory legislative scope to voluntarily apply principles of the three pillars of social responsibility – the economic, the social and the environmental – for their activities to be considered really socially responsible. To tell the truth, the ISO 26 000 standard, used as the basis for the evaluation, much corresponds in the key area KO-2 with legislative requirements of the Czech Republic, and as all evaluated faculties comply with valid Czech legislation, their rating in this area was very high despite the fact that they hardly step beyond their legislatively defined obligations.

The key area KO-4 Environment proved to be problematic ***for all analysed faculties***. All three scorings were below the median value of 2. FEA was scored with 1.73, FBE with 1.36 and FBM with 1.18. Environment area is on a rather low level at each of the three faculties. All of them are only engaged in waste recycling, energy saving and other natural resource sparing. The environmental criterion is only considered in the context of public tendering by FEA. The faculties do not take any further steps towards specific activities in this area. And yet the role of the environment and its protection is prioritised now and the stakeholders are interested in how the organisation they are related to addresses the environmental issues. This is confirmed for example by Flammer (2013), who says that shareholders are sensitive to corporations' environmental footprint and they react positively to the announcement of eco-friendly initiatives.

In all other key areas, namely KO-3, KO-5, KO-6, and KO-7, FEA was always above the median level 2 and the other two faculties FBM and FBE either tightly reached the median value of 2 or were below it.

In KO-3 Labour practices the main difference between FEA and FBM, FBE was in communication with employees and overall benefits in excess of legislative requirements (working hours of academic staff and academic club). FEA emphasizes employee satisfaction and good labour relationships.

In the key area KO-5 Fair operating practices FEA, again rated higher than the other two faculties, in addition examines and promotes corporate social responsibility in relation to its partners. The faculty does not partner with anybody and chooses socially responsible partners. In addition, the CSR criterion is considered in the context of public tenders.

In the ***key area KO-6 Consumer issues*** the main difference between FEA and FBM and FBE was in communication with students and feedback provision to their comments and suggestions considered by FEA as very important. In addition, FEA has the "Teresiás" organisation for work with and assistance to handicapped students.

FEA achieved a significantly better score in the last key area ***KO-7 Community involvement and development*** again when compared to the other two faculties, FBN and FBE. Its engagement focused on the community is again far above the other two, with the highest number of community-focused programmes. Also its approach to community education – not straightforward subsidy provision but teaching how to earn the needed money – may be a good example to follow by others.

The results therefore confirm the basic assumption that corporate social responsibility should be built into strategic management of universities without which CSR development at the university cannot be sufficient. Analyzed HEIs in the Czech

Republic perform many socially responsible activities but not always in the targeted manner and often as by-products of other activities. This is the first thing to be changed. CSR activities at HEIs must be strategically planned and organized, promoted to partners, employees, students and other stakeholders. HEIs should take corporate social responsibility as one of their strategic goals, include it into their long-term orientations and other strategic documents and have their activities governed by that. Hahn (2013) emphasizes the need for CSR planning and strategic building into organisation activities with awareness of what is not appropriate and ethical. At the same time, however, he points out that building social and environmental aspects into corporate strategies is not easy and requires willingness and readiness to accept CSR as one of the corporate values. In addition, social responsibility of conduct is perceived with great sensitivity by the surrounding stakeholders and the society. And where the HEI itself behaves with social responsibility in mind, it can serve as an example to follow by others. Important aspects of this activity also include CSR activity reporting and communication. The annual report on CSR, information about CSR in annual reports, on corporate web sites and in social networks should go without saying. Support in this key area may come from the existing CSR platforms which HEIs can become members of.

Another important proposal for improvement is enhanced communication with all stakeholders both in the key area KO 3 – Labour practices and in KO-5 Fair operating practices as well as KO-6 Consumer issues. The need for and role of communication with and between employees, students, partners and other stakeholders is crucial. Every stakeholder my contribute specific suggestions which may significantly shape the development and face of CSR and elsewhere. Where sufficient room for communication is not provided the status quo cannot be improved. If HEIs learn to consider all stakeholders including the community and listen to their needs they can create really socially responsible environment together.

The third suggestion for change is focused on targeted effect on long-term sustainable consumption both in the key area KO-4 environment and in KO-6 Customer issues as well as KO-7 Community involvement and development. University as an educational institution can affect conduct of its students, employees and the community as a whole. Hence the importance of targeted teaching focused on corporate social responsibility and environment protection not only for undergraduate students but also in the form of specific educational and other community focused activities.

Like in the profit sector in the area of tertiary education too social responsibility may help HEIs improve their image, public relations, increase employee loyalty and attract talented students and high-standard employees.

Limitations of the performed research mainly lie in the recommending and self-evaluating nature of the ISO 26 000 standard, involving the element of individual perception and evaluation by the project team and individual respondent setting. The differences between the analysed faculties might in some case be also affected by this aspect.

Focus of further research on more different areas might be beneficial. The research sample of the assessed schools should in future be extended by other public and private universities of the Czech Republic and other countries. Further research might also try to find out whether there are differences between actual and declared CSR activities in the tertiary education sector. Othman and Othman (2014) states that CSR is often seen by critics as little more than a public relations exercise designed to give the appearance of social responsibility while in reality doing nothing to change corporate priorities or operating practices. Also the effects of inclusion of the CSR concept in HEIs on their performance and other aspects of their activities have not been sufficiently described yet.

Conclusion

The presented research results are a part of the complex research of the CSR in the tertiary sector. The case of faculties of economics at public universities in the Czech Republic shows that corporate social responsibility does exist in the tertiary education sector in the Czech Republic and develops too but is not yet always implemented in a targeted manner in the school strategies, appropriately communicated and reported. That is also one of the main drawbacks of the assessed faculties. The main output of the research is the finding that the HEIs with the CSR concept built in their strategic documents are more widely engaged in most of the key areas evaluated pursuant to ISO 26000. This also confirms the above assumption that corporate social responsibility should be built into strategic management of universities without which CSR development at the university cannot be sufficient. This fact is clearly demonstrated by the evaluation results of FEA of Masaryk University in Brno. Social responsibility may only be pursued and implemented in organisation activities well on condition of the organisation management´s favourable and understanding approach to the need of its development.

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GENDER INFLUENCE ON STUDENTS' REQUIREMENTS OF EMPLOYEE BENEFITS

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Highlights

- *Students of analysed faculties require similar benefits*
- *Only in case of some benefits there was found a relation to the gender of students*
- *The most desired benefits are Contribution to corporate catering, and Use of company car*

Abstract

The article presents the partial results of research on the requirements of students, members of the Generation Y, in providing employee benefits. The research was conducted in the period between 2002-2014 among master students of Mendel University in Brno. The paper examines whether the gender of the respondent influences the set of desired employee benefits. There were identified the top ten most requested benefits, for which there was done the analysis of their correlation with the gender of respondents and in the case of three of them there was identified a repeated (in more years) statistical correlation: Coverage of language courses, Additional salary (Midyear bonus), On-site parking. Correlations were also examined in the case of additional 30 benefits and in the case of 4 of them there was identified a repeated (in more 5 years) statistical correlation: Children's nurseries and kindergartens, Share on profits, Contribution to recreation and Contribution for Christmas (Annual bonus).

Keywords

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Introduction

Employee benefits are such forms of rewards that an organization provides to employees just because they are its employees. Benefits are usually not attached to the performance of the employee. In providing the benefits there is often taken in consideration the status of employees in the company, the period of employment in the organization and their merits. Similarly, the benefits are defined by Armstrong (2009), BLS (2005) and Kleibl, Dvořáková and Šubrt (2001), who consider the benefits as an element of reward provided for remuneration, in addition to various forms of monetary rewards.

According to many authors (DeCenzo and Robbins 1999; Dvořáková, 2007) benefits represent an essential part of a functioning employee motivation program, because they have a significant impact on whether the employee will remain in the company. This view is supported by research among readers of Employee Benefits magazine (2013) – users of a server, which investigated the reasons for provision of employee benefits by employers. Majority of employers ranked to the top reasons their effectiveness as a tool for attracting and retaining staff. The top reasons also included an effort to reward employees, promote their well-being and health, aim for a work-life balance. Attracting new employees is not only based on the provided employee benefits – there are other important characteristics of a company, e.g. a good working atmosphere, and career advancement opportunities (Backes-Gellner and Tuor 2010). Benefits, though, become an important criterion of acceptability of a job offer. According to Provazník and Komárková (1996), Dulebohn, Molloy, Pichler and Murray (2009), in the case of specific tangible rewards for employee benefits, they consider that except objective value of a benefit its subjective value is often more important, depending on how it is perceived by the recipient. The subjective value contains symbolic meanings. Specifically, distinctive material rewards, if they are accurately targeted to the current situation of the recipient, are more stimulating than money. Employees perceive interest in them, they realize that they are valuable for the company, their self-esteem and sense of responsibility are increasing, and a sense of belonging reinforces in them, which eventually increases their self-identification with business objectives. Horská (2009) contends that the benefits are considered as hygiene factors (Herzberg, Mausner and Synderman, 2004). According to the author, if the benefit is withdrawn it leads to demotivation of employees. This view is supported by research of Vnoučková (2014). Benefits are also less demanding than the economic exploitation of wages, because many benefits are tax-supported (e.g. Hammermann and Mohnen 2014; Macháček, 2013; Duda, 2011; Grubb and Oyer, 2008). Employees also expect a fair administration of the benefits (Muse and Wadsworth, 2012).

It is necessary to note, as Armstrong (2009) and Hewitt Associates (2002) state, that employee benefits are also a very expensive part of the total set of tangible rewards, they may represent up to one-third of the wage-costs, and must be carefully planned and managed. Globalization, outsourcing, a shift from manufacturing to a service economy, and limited economic growth have greatly impacted employee benefits in the recent years. Compensation has declined, whereas employee expectations of future salary increased.

In the Czech Republic there are cannot be found many research enquiries in the field of employee benefits. There exists, though, a long-term collaboration of the company NN (2015) with the Confederation of Industry of the Czech Republic, which addresses these issues. Results of their research are shown in Table 1. Among the most common benefits provided

by the companies, there belong cellular phone for private use, employee´s professional development, medical checks, drinking regime and contribution to corporate catering. Results also showed the following key findings: 99 % of companies do provide employee benefits, and on average they provide 12 employee benefits. Menu of the benefits also includes less traditional benefits e.g. medical checks, sick days etc.

Employee benefits	2010	2011	2012	2013	2014	2015
Cellular phone	80 %	84 %	75 %	87 %	89 %	88 %
Employee professional development	70 %	78 %	82 %	85 %	81 %	83 %
Medical checks	-	-	-	75 %	78 %	77 %
Drinking regime	71 %	79 %	71 %	82 %	75 %	81 %
Contribution to corporate catering	75 %	68 %	81 %	82 %	74 %	72 %
Use of company car for private purposes	75 %	80 %	75 %	76 %	74 %	73 %
Benefits in kind/single-time benefit	57 %	64 %	64 %	71 %	71 %	66 %
Contribution to pension insurance	60 %	71 %	74 %	68 %	68 %	77 %
Contribution to life insurance	39 %	54 %	43 %	53 %	49 %	60 %
Contribution to sports	33 %	32 %	39 %	40 %	42 %	35 %
Additional salary (Midyear bonus)	32 %	37 %	37 %	39 %	39 %	47 %
Contribution to health (vitamins etc.)	24 %	31 %	35 %	36 %	39 %	36 %
Contribution to cultural events	29 %	28 %	33 %	41 %	35 %	42 %
Employee loans	31 %	32 %	36 %	38 %	34 %	40 %
Vaccination against flu	24 %	28 %	25 %	35 %	27 %	31 %
Contribution to recreation	20 %	24 %	28 %	32 %	27 %	30 %
Sick days	-	-	-	30 %	25 %	33 %

Table 1: Employee benefits provided by companies in the Czech Republic in 2010-2015 Source: NN, 2015

The notion of Generation Y first appeared in 1993 in the journal "Advertising Age", and it referred to the generation of children born in 1985-1995 (Constantine, 2010). However, some authors shift the year of birth beyond 2000, even to 2004 (e.g. Clark, 2007; Beekman, 2011, and others). Strauss and Howe (2010) define the interval of birth using years 1982-2004. Alexander and Sysko (2012) even refer to the interval of 1982-2009.

This generation is often referred to by different names. These include the Internet and the digital generation, the click generation, echo boomers (Balda, 2011; Kopecký, 2013). Mainly in the USA (e.g. Evans, 2011; Jayson, 2012), the Millennials (Children of the millennium) is often used. Most of Generation Y is entering the labour market right now and if the employers want to attract the best talented people, they have to adapt to their requirements not only in their recruitment policies, but also in their approach to these young workers.

People born in this generation like to try new challenges, overcome obstacles, and are not afraid to express their opinion. They are practical, optimistic and confident in the future and a better tomorrow (Evans, 2011). It is the first "global" generation communicating, discussing, and sharing information right over the internet. Generation Y has sustained access to computers and mobile phones since their youth, and they require their employers to allow the daily use of these technologies in the context of professional life, too (Stojanová, Tomšík and Tesařová, 2015; Kubátová and Kukelková, 2013; Evans, 2011; Eisner, 2005). According to Kociánová (2012), the people of Generation Y should form the bulk of the working age population till 2025. Unlike their predecessors, who lived for work, for the younger generation the balance between personal and professional life is quite crucial, and they work to live.

Young people see modern technology as a normal part of their lives and they want to use them. In addition, they are also flexible and eager to be judged by the results of their work, regardless of when, where and how they execute it. Also Bannon, Ford and Meltzer (2011) and Kubatová and Kukelková (2013) are considering Generation Y workers more flexible than previous of workers of Generation X.

The authors Stojanová, Tomšík and Tesařová (2015), Hershatter and Epstein (2010) and Tulgan (2009) point out that the requirements of Generation Y at the labour market are very specific, and the future employers must take into account their potential for satisfaction of these requirements. According to them, this generation values most the long-term education followed by gaining experience in the areas covered by their company. Generation Y emphasizes the long-term effect, not only at work but also in their personal life, education, investments, prefers the efficiency of time and resources. According to Kopecký (2013) the companies should concentrate on the formation of incentive programs, attractive work environment and a comprehensive system of human resource management. Acquisition, motivating and retaining the best Generation Y employees can be dealt with in a similar way as the company treats its customers. Hays, a consultancy company conducted a survey in 2013, which examined the factors influencing generation Y, when choosing their future employer. The results showed that most influential are the existence of training and development programs, employee benefits, and time flexibility of employment. Important factors also include the possibility of rapid career progress, and well-defined career path (Kazdová, 2014). The opposite opinion has Vysekalová (2011), according whom this generation does not seem to know exactly how their career should look like, but they are much more demanding in their requirements for employers.

The aim of the paper it to examine, whether the gender of the respondents – members of the Generation Y – influences the set of required (desired) employee benefits. The paper significantly extends the paper (Duda, 2016) presented at the 6th International Conference on Management (ICOM 2016) organized in June 2016 in Brno. There are elaborated deeper and fuller analyses related to the demands of students on provision of employee benefits by their future eployers. There are statistical analyzes of the results.

Materials and Methods

Respondents are students of the master-level courses "Human Resources Management" and "Business Management" at the Faculty of Business and Economics, and the Faculty of AgriSciences, Mendel University in Brno, and the time horizon of the research presented in this paper covers the academic years 2002/2003-2013/2014. Within these 12 academic years, students participated in research focused on the area of employee benefits. As the first part of the research students were asked to

fill-in a questionnaire with 40 employee benefits that could be expected from their future employers. Students were asked to assess the individual employee benefits in terms of the level of interest in their provision. Students assessed the attractiveness of particular employee benefit on a 4-point scale ("definitely yes", "probably yes", "not necessarily" and "definitely not"). The paper analyses the results of student responses with the degree of interest in providing benefits evaluated as "definitely yes".

Over the years the number of survey respondents totals to 1,442 students of Faculty of AgriSciences, and 2,274 students of the Faculty of Business and Economics. Numbers of students in respective years of research ranged from 175 to 321 students. This corresponds with approx. 70-90 % of all students studying the final year of their study programme.

Selected contingency tables were compiled, both with empirical frequencies (n_{ij}) and expected frequencies (n'_{ij}) in order to conduct statistical analysis of the dependence. The chi-square (χ^2) test criterion was used to analyse this, and in case of an identified correlation, the intensity of correlation was calculated using the Pearson's contingency coefficient (P) (Stávková and Dufek, 2004).

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

$$P = \sqrt{\frac{\chi^2}{\chi^2 + n}} \quad (2)$$

For comparison, the order of preference of employee benefits there has been used the Spearman's rank correlation coefficient (r_s) as described in Stávková and Dufek (2004). Through Spearman correlation coefficients the responses of students were rank-ordered, and there were identified the ten most frequently required employee benefits, which were also compared between the two faculties. The more the two rankings match the more this ratio approaches 1, the more the rankings differ the closer to -1 the ratio gets.

$$r_s = 1 - \frac{6 \cdot \sum_i \left(a_i - b_i\right)^2}{n\left(n^2 - 1\right)} \quad (3)$$

where:

a_i represents the ranking of the particular benefit as evaluated by the students of the Faculty of Business and Economics, and b_i the ranking by the students of the Faculty of AgriSciences, and n is the number of benefits

Coefficient r_{sRA10} represents the value of the Spearman correlation coefficient for student responses indicating the order of answers "definitely yes" within the ten most frequently mentioned employee benefits.

Coefficient r_{sRA5} represents the value of the Spearman correlation coefficient for student responses indicating the order of answers "definitely yes" within the five most frequently mentioned employee benefits.

Results and Discussion

The first step represented frequency analysis, based on which there was determined the ranking of the benefits mostly demanded by the students of a particular faculty. The most important benefits (top ten) are: contribution to corporate catering, additional salary (Midyear bonus), use of company car, additional week of holiday, on-site parking, covering language courses, contribution to pension insurance, contribution to life insurance, employee discount on company product and services, contribution on retirement. Students tend to assign the particular benefits with a similar importance. Spearman rank correlation coefficient of benefits throughout the research is r_{sRA10} = 0.89 among the top ten benefits, and r_{sRA5} =0.85 among the top five (Duda, 2015).

As can be seen from the calculated values, ranking of the preferred benefits has significant statistical similarity. Based on the results, we can conclude that students of both faculties subject to the research have similar preferences of employee benefits.

For the most favourite employee benefits according to the frequency of their order, which was found in the previous calculations in Table 2, there can be seen a more frequent correlation with the gender of respondents only in the case of two benefits – on-site parking, and covering language courses.

Year/ benefit	contribution to corporate catering	use of company car for business reasons	on-site parking	covering language courses	additional week of holiday
2002/2003	0.026	2.531	4.057	4.510	1.456
2003/2004	3.703	0.570	3.213	4.104	4.162
2004/2005	9.146*	2.267	6.661	4.580	1.909
2005/2006	2.422	3.522	15.426**	8.099*	2.806
2006/2007	3.549	2.233	0.703	14.102**	3.887
2007/2008	3.433	1.541	6.576	10.903**	4.694
2008/2009	2.640	2.712	1.311	19.398***	6.088
2009/2010	0.403	1.099	8.160*	7.901*	0.666
2010/2011	7.747*	3.600	2.685	12.973**	5.553
2011/2012	5.576	0.728	13.923**	22.504***	6.890
2012/2013	1.972	3.587	6.033*	13.955**	0.696
2013/2014	4.893	8.957*	7.167	6.698	2.971

, **, * Significant at 0.05, 0.01, and 0.001, respectively. Source: own processing*

Table 2: Results of the respondents' gender correlation with the "top five" benefits

For the on-site parking the correlation with the gender of respondents was identified in four of the 12 monitored years, the intensity of correlation was mild to moderate. Using the coefficient of association, it was found, that this benefit was more preferred by women.

Currently, parking in the vicinity of the employer often becomes problematic, so this benefit becomes more desired. Employers should respond to this situation and adapt their range of benefits. In the USA, this benefit (on-site parking) is often offered by employers. A survey by the Society for Human Resource Management (2013) states eighty-seven percent of organizations offer on-site parking. The importance of on-site parking is also confirmed by research "Survey of Reward Management" (Armstrong, 2009), where this benefit occupies the third place among the most frequently provided benefits (provided by 74 % of respondents). Big popularity among students was gained by the coverage of language courses, which shows that students realize the importance of foreign language skills. In contrast, businesses should be aware that students may have problems

with professional communication in a foreign language, and it is in the interests of the company as a part of employee training to enable students to fill this potential gap. This employee benefit belongs to those, for which there has been frequently demonstrated a correlation with the gender of respondents (within the eight years of research) – more frequently preferred by women.

These two benefits – On-site parking, and Coverage of language courses – were most frequently demanded by students, and they ranked among the top five, i.e. five most desired benefits required by students from their future employers.

Another benefit included in the top ten based on the frequency of ranking was the additional wage (Midyear bonus). For this benefit there has been demonstrated a dependence on gender in four years of research. Dependence was evaluated as moderate to high. In the case of the other employee benefits, which were included in the top ten according to the frequency of the ranking (see Table 3), there has not been identified any statistically significant correlation with the gender of respondents more than twice in the 12-year time-series (Contribution to corporate catering, Use of company car for business reasons, Contribution on retirement, Employee discount on company products and services, Contribution to life insurance) respectively none correlation at all (Extra week of holiday, Contribution to pension insurance).

The most important employee benefits for students, regardless of the gender, according to the survey represents the contribution to corporate catering. This employee benefit is a fixture and its provision is financially beneficial to both parties. Contribution to corporate catering brings tax advantages for employers in the Czech Republic (Czech National Council, 1992). Macháček (2013) and Duda (2011) state that employees have a lower price for meals, and the employer has a control of the level of costs for meals. The top position of the contribution to corporate catering among employee benefits is also confirmed by Kučera (2011) in his comprehensive study "Pay Well" done in cooperation with PricewaterhouseCoopers. Research of Ministry of Labour and Social Affairs (2015) states that the contribution to corporate catering was provided in about 95 % of collective agreements of all employers.

In a survey conducted by company NN (2015), Contribution to corporate catering is provided by almost 75 % of the companies. Financial contribution to food is reflected in the attractiveness of employers and sends a signal to potential job seekers (Backes-Gellner and Tuor, 2010).

Employee benefits Extra week of holiday and Contribution to pension insurance belong to the popular benefits required by students, representatives of Generation Y.

For employees of companies in the Czech Republic extra week of holiday represents a very valuable benefit, as confirmed by Přikryl (2012) in the study Salary & Benefits Guide 2011-2012 of the Company Robert Half and Kučera (2011). Research conducted by the Ministry of Labour and Social Affairs (2015) also states that extra week of holiday is the second most common benefit provided by employers. Importance of the benefit is also confirmed by Armstrong (2009) in the study "Survey of Reward Management", where the benefit is also the second most frequently provided benefit (provided by 81 % of respondents).

The importance of an extra week of holiday confirms Kolerová (2014), who compared the development of employee benefits provided in the Czech Republic as processed by Profesia 2007-2012. This benefit is ranked in the top five rankings of provided benefits on the second place. This benefit, according to this survey, was available for 25 % of the respondents. The pension insurance was available for 25 % of the respondents. This research was attended by 66 374 respondents.

Providing the benefit Contribution to pension insurance was confirmed by the survey of Sodexo (2005) and NN (2015). Contribution to pension insurance provide 36 % of companies (Sodexo, 2005) or 77 % of companies (NN, 2015).

Year/ benefit	contribution on pension leave	Additional salary (Midyear bonus)	employee discount on company product and services	contribution to pension insurance	contribution to life insurance
2002/ 2003	3.390	4.026	1.665	2.038	0.347
2003/ 2004	1.466	12.588**	1.752	5.126	5.862
2004/ 2005	2.571	4.256	1.443	2.297	2.881
2005/ 2006	2.381	8.923*	3.882	3.762	1.974
2006/ 2007	2.027	17.815***	1.436	5.362	5.567
2007/ 2008	2.190	12.998***	0.817	1.699	13.327**
2008/ 2009	6.777	14.271**	8.154*	0.557	10.492*
2009/ 2010	3.115	7.709	7.673	3.109	1.281
2010/ 2011	13.506**	7.548	2.132	0.408	2.418
2011/ 2012	1.032	4.158	9.408*	4.821	0.417
2012/ 2013	6.044	5.133	0.597	5.299	1.724
2013/ 2014	10.063*	6.059	0.285	6.064	5.016

, **, * Significant at 0.05, 0.01, and 0.001, respectively. Source: own processing*

Table 3: Results of depending on the respondents' gender on „top ten" benefits

Because of the volume of the data, there were only selected those benefits, in case of which there was identified a correlation with the gender of respondents in the minimum of 5 years.

In the case of the remaining 30 benefits, repeated correlation with gender was identified in the case of 4 of them (see Table 4): Children's nurseries and kindergartens, Share on profits, Contribution to recreation, Contribution for Christmas (Annual bonus).

The most frequently identified correlation with the gender of respondents relates to the benefit Children's nurseries and kindergartens, which occurred in eight of the 12 years of research – mostly preferred by women. The level of significance was also very high ($\alpha = 0.001$). This benefit has recently become very demanded in the Czech Republic. There was a shortage of places in kindergartens, and many companies have decided to address this issue by building their own corporate kindergartens.

These efforts were also supported by government subsidies for establishing the corporate kindergartens (Ministry of Education, Youth and Sports Czech Republic, 2004).

Another benefit, for which there was often identified a statistical dependence on respondents' gender was Contribution for recreation. The gender dependence was confirmed in the total of seven years of research (of the 12 in total), and there was identified a higher preference of this benefit by women. The correlation was mild to moderate. Conversely, the benefit Share on profits was preferred by men, and in total there was identified a correlation with the gender of respondents in six years of research; strength of the correlation was moderate. In five years of research there was also identified a gender correlation of preference of the benefit Contribution for Christmas (Annual bonus), the strength of correlation was mild to moderate, and this benefit has been preferred by women.

Year/benefit	Children's nurseries and kindergartens	Share of profits	Contribution to recreation	Contribution for Christmas (Annual bonus)
2002/2003	24.879***	6.712	14.065**	6.926
2003/2004	13.454**	1.511	13.131**	14.019**
2004/2005	6.086	11.571**	8.090*	5.897
2005/2006	4.954	1.004	3.386	8.054*
2006/2007	2.934	15.461**	9.043*	14.733**
2007/2008	19.254***	10.955*	7.378	6.963
2008/2009	16.447***	6.545	10.238*	12.679**
2009/2010	32.832***	7.029	3.312	5.035
2010/2011	15.472**	6.509	9.222*	6.779
2011/2012	24.451***	17.254***	5.114	6.502
2012/2013	7.130	14.422**	2.765	3.767
2013/2014	37.5147***	8.641*	12.086**	10.967*

, **, * Significant at 0.05, 0.01, and 0.001, respectively. Source: own processing*

Table 4: results of depending on the respondents' gender on selected benefits

For 7 other benefits there was identified a correlation with the gender of respondents in minimum of 4 years – Provision of employee stocks, Use of company car for private reasons, Sports vouchers for swimming, Christmas box of chocolates for children, Contribution to cultural events, Children's camp, Corporate accommodation.

Men preferred the benefits Provision of employee stocks, and Use the company car for private reasons. The strength of correlation was mild. Popularity of this employee benefit (Use the company car for private reasons) confirms the research the company NN (2015). This employee benefit is provided by 73 % of companies. Women preferred the benefits Sports vouchers for swimming, Christmas box of chocolates for children – dependence of preference on gender was evaluated as moderately or highly probative. Other employee benefits preferred by women included Contribution to cultural events, Children's camp, Corporate accommodation. In the case of these benefits, the correlation with the gender was evaluated as mild.

Conclusion

General recommendation emanating from the performed research is that when creating a system of employee benefits, the employer should respect the gender of potential employees. The employer must properly decide whether the benefits will be motivational.

An important finding is the fact, that for the most preferred benefits – Contribution to corporate catering, Use of company car for business reasons, Additional week of holiday – there was not identified a correlation with respondent's gender. In the case of the other most desired benefits there has been identified a repeated correlation with respondent's gender for 3 of them: Coverage of language courses, Additional salary (Midyear bonus), On-site parking.

For the other analysed employee benefits there was identified a repeated statistical correlation with the gender in the case of Children's nurseries and kindergartens, Share on profits, Contribution to recreation and Contribution for Christmas (Annual bonus).

For majority of the analysed benefits there was identified certain dependence on gender of respondents. Women mostly preferred these benefits: Coverage of language courses, Children's nurseries and kindergartens, Contribution for Christmas (Annual bonus), Contribution to recreation. Men mostly preferred the benefits Share of profits, Provision of employee stocks, Use of company car for private reasons.

The gender is very sensitive aspect not only at state owned institutions, but also at private companies. To comply with the results of analyses performed in this paper, the cafeteria system seems to be a good option, as well.

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STUDENTS' MATHEMATICS KNOWLEDGE – THEORY AND EXERCISES

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Highlights

- *Knowledge tests – relationship between the ability to formulate definitions and to solve exercises*
- *Most common errors in formulations of the selected definitions*

Abstract

The article analyses the test results evaluating the knowledge of students of basic mathematics courses at the University of Economics in Prague and at the University of Finance and Administration in Prague. The relationships between the study of the theory, the ability to formulate definitions and to solve exercises are analysed based on the results in two groups of students of the University of Economics. For this purpose the statistical evaluation utilizing the log-linear models is used. The success rate in formulating definitions in two groups of students of both universities is compared using hypothesis testing. The most common errors in the theoretical parts of the tests are presented.

Keywords

Definition, exercise, log-linear model, mathematics, test, theory

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Introduction

The article is an extension of the paper presented at the 12th International Conference on Efficiency and Responsibility in Education (ERIE 2015) (Ulrychova, 2015).

The article deals with the teaching of mathematics (the specific parts of linear algebra, in particular) at two universities of economic studies in Prague – at the University of Economics (a public school) and at the University of Finance and Administration (a private school). It focuses especially on the theoretical part – it is assessed whether the knowledge of theory affects the ability to solve exercises positively. Moreover, the success in the formulation of definitions is compared for students of both universities and most common errors in the theoretical part are presented. These results lead to ponder to what extent it is necessary to emphasize theory and to demand the exact wording of the definitions in mathematics education at universities of economic studies.

Students' performance at universities can depend on their high school mathematics knowledge (cf. (Kučera and Svatošová and Pelikán, 2015)). Some students, who were not successful in their mathematics study at high school, suffer from mathematics anxiety (Ashcraft and Moore, 2009) at universities. Many students dislike mathematics based on their experience at high schools.

Students of universities of economic studies are usually not proficient enough in basics of high school mathematics and they are not used to formulate mathematical definitions and theorems. They were not led to the logical thinking; they were taught to math skills without real understanding of the matters. It is difficult to change the students' approach to the study of mathematics at university, particularly when a small number of lessons is available.

Students prefer comprehensible way of teaching, not very focused on the theory – such a way that does not stress them by its complicated form. This also corresponds to experience with other European universities – see e.g. (Widenská, 2015). For example, Oldknow (2009) and Widenská (2014) consider the including of information and communication technology as a way of making the study of mathematics more attractive.

The mathematics curriculum at the University of Finance and Administration is taught with a stronger emphasis on the understanding against a memorization only. Therefore, the curriculum is interpreted as simply as possible in mathematics lessons and – compared to the University of Economics – students are allowed to formulate the theory less formal during the oral exam, e.g. by words instead of a formal mathematical notation. In this article, we compare the results in groups of students of both universities in order to find out if this way of interpreting of mathematics curriculum brings better results. However, the results can be also affected by different levels of students' skills regarding to different characters of the universities (a public and a private school).

The basic mathematics course at the University of Economics in Prague is taught for a period of one semester within the range two lessons of lectures and two lessons of seminars per week. It includes the basics of mathematical analysis and linear algebra in the range corresponding with textbooks such as (Batíková, 2009) or (Klůfa and Kaspříková, 2013).

Except for the final exam consisting of a written test and an oral part at the end of the semester, students of mathematics course are tested using a written test in the middle of the semester. The result of this test is counted towards the result of the final exam – more in (Otavová and Sýkorová, 2014). Until the academic year 2009/2010, these mid-term tests consisted of exercises only. In summer semester 2009/2010, the author of this article included (as a part of the research for her doctoral thesis) an extra task to formulate given definitions into the mid-term test.

The basic mathematics course at the University of Finance and Administration is taught for a period of two semesters within the range two lessons of lectures and one lesson of seminars per week. It includes curriculum similar to the curriculum at the University of Economics – see the textbook (Budinský and Havlíček, 2005).

In each of the two semesters, the course is completed with a credit and an exam. To award the credit, students are required to pass a written test. The credit is a prerequisite for taking the exam. The exam consists of a written part and a verbal part; prerequisite for taking the verbal part of the exam is to pass the written part. The both credit and exam written tests consist of exercises only. In the academic year 2015/2016, the author of this article included into the credit test at the University of Finance and Administration the same extra task as at the University of Economics in the academic year 2009/2010.

The primary aim of this article is to evaluate the effect of the study of the theory for the results of the tests and to assess the relationships between the study of the theory, the ability to formulate the definitions and the ability to solve exercises. Another aim is to compare results at two similarly oriented universities. Although the research was focused primarily on tests from the area of linear algebra and on students of the University of Economics (see also (Kaspříková, 2012)) and of the University of Finance and Administration, the results could be transferable to other fields of mathematics and other similarly oriented universities (see e.g. (Milková, 2011), (Brožová and Rydval, 2014)).

Materials and Methods

In the academic year 2009/2010, three teachers of the Department of Mathematics at the University of Economics in Prague administered mid-term tests with the theoretical part to 300 students of different study groups and fields of study. Students were required to formulate following five definitions: linear combination of vectors, linear dependence of vectors, rank of a matrix, invertible matrix, matrix inversion. They had not expected this theoretical part in the test and it can be assumed that they had not prepared for that. Students were informed that the results of this part would not be taken into account for the official rating of the tests and they were asked to try to formulate the definitions in the best way they can.

The theoretical part in all the tests was evaluated by the author of this article. The correctness of formulations and the most common errors were determined (in detail in (Ulrychová, 2013)). The evaluation of the accuracy of formulations was very moderate – for example, the non-generic definition of linear combination of vectors expressed just for two vectors was accepted as correct. In addition, in the case of tests comprising an exercise related directly to one of the five given terms, the relationship between the correctness of the solution of the exercise and the correctness of the formulation of relevant definition was examined.

In the academic year 2010/2011, the head of Department of Mathematics made it mandatory to include a task to formulate one definition or theorem (not necessarily from linear algebra field) in all mid-term tests. Students were informed in advance about this fact and the results of this part were counted towards the official rating of the tests. In that year, the author of this article took the exceptional opportunity to compare the results of the tests in the group of students who did not expect the theoretical part in the test (the group *A*) with the results of tests in the group of students who did expect this part (the group *B*).

In the academic year 2015/2016, the author of this article repeated the experiment from year 2009/2010 (the group *A*) under the same conditions by administering credit tests at the University of Finance and Administration (the group *C*).

Results of all students (of chosen teachers), who passed mid – term tests (credit tests, respectively) in regular terms, are included in the experiment in all three cases (the groups *A*, *B*, *C*). The results of students in these groups are compared. Attention is focused on the theoretical part; the ability to formulate the definitions is assessed and the most common errors are described.

The character of the groups *A* and *B* allows us to assess the effect of study of the theory on results in both theoretical and practical parts of the test. For this purpose, the relationships between the study of the theory, the ability to formulate definitions and to solve exercises are analysed using log-linear models (Agresti, 2002) for the groups *A* and *C*.

Let´s denote T = the student did/did not expect the theory in test, E = the exercise was/was not correct and D = the definition was correct/incorrect.

The level of dependence in each of pairs „the student can/cannot formulate the definition – the student can/cannot solve the exercise" (pair DE); „the student can/cannot formulate the definition – the student did/did not expect the theory in test" (pair DT); „the student can/cannot solve the exercise – the student did/did not expect the theory" (pair ET) is examined.

The log-linear hierarchical models (saturated, homogeneous association, conditional independence, joint independence) and function "glm" (generalized linear models) in R-software are used to determine the best model in each category. The statistical tests of their feasibility were performed using the standard statistical testing of submodel (the deviance test) (see (Agresti, 2002)).

The saturated model corresponds to reality (obtained data). In the homogeneous association model all three pairs DE, DT, ET were retained (denoted DE.DT.ET). In the conditional independence model (a reduced model of the homogeneous association model) one of the pairs DE, DT, ET was always omitted. Among these reduced models, the one which best coincided with the reality (and with the homogeneous association model) was chosen. The pair, whose omission leads to the least breach of the accordance with reality, shows the weakest relationship between its members (compared to the other two pairs). In the joint independence model (a reduced model of the conditional independence model) another pair was omitted and again the model conforming the best with the reality was chosen. In the pair, which remained as the last, the relationship between its members is the strongest compared to the other two pairs.

The character of the groups *A* and *C* allows us to compare the success in formulation of definitions of students of two similarly oriented universities. The hypothesis test of equality of relative frequencies of alternative distribution is used for comparison of the results in groups *A* and *C* – see e.g. (Bílková, Budinský and Voháňka, 2009).

In two independent random samples (the groups A and C) of large sizes n_1 and n_2 the null hypothesis H_0: $\pi_1 = \pi_2$ is tested at the 5% significance level against the alternative hypothesis H_1: $\pi_1 \neq \pi_2$, $\pi_1 < \pi_2$ and $\pi_1 > \pi_2$, respectively. The test criterion

$$U = \frac{P_1 - P_2}{\sqrt{\overline{P}\left(1-\overline{P}\right)}} \cdot \sqrt{\frac{n_1 \cdot n_2}{n_1 + n_2}}, \quad (1)$$

where

$$P_1 = \frac{M_1}{n_1}, P_2 = \frac{M_2}{n_2} \quad (2)$$

(relative frequencies) and

$$\overline{P} = \frac{M_1 + M_2}{n_1 + n_2}, \quad (3)$$

is used.

The corresponding critical ranges are $W\alpha = \{u; |u| \geq u_{1-\alpha/2}\}$ for the alternative hypothesis H_1: $\pi_1 \neq \pi_2$, $W\alpha = \{u; u \geq u_{1-\alpha}\}$ for H_1: $\pi_1 > \pi_2$ and $W\alpha = \{u; u \leq -u_{1-\alpha}\}$ for $\pi_1 > \pi_2$.

For $\alpha = 0.05$, the critical values are $u_{1-\alpha/2} = u_{0.975} = 1.960$ and $u_{1-\alpha} = u_{0.95} = 1.645$.

Results

Evaluation of Tests in the Group A (The University of Economics in Prague)

The group A is the group of 300 students who did not expect the theoretical part in the test. Table 1 shows the number of correct answers in group A.

	number	%
linear combination	93	31%
linear dependence	89	29.67%
matrix rank	186	62%
invertible matrix	205	68.33%
matrix inversion	95	31.67%

Tab. 1: Success rate in formulating particular terms (the group *A*)

As we can see in Table 1, in three cases (linear combination of vectors, linear dependence of vectors, matrix inversion) the success rate was about 30%, in the case of rank of a matrix and invertible matrix the success rate was more than double (62% and 68% respectively). Interestingly, the terms rank of a matrix and invertible matrix are built on the term linear dependence and hence on the term linear combination, formulation of which was much less successful.

In addition, the relationship between knowledge of the term rank of a matrix and invertible matrix, respectively, and the terms on which these terms are built (linear dependence and linear combination) was examined. As we can see in Table 2, 186 students (out of 300 total) defined correctly the term rank of a matrix but only 41 (i.e. 22%) of them defined correctly the remaining terms. Only 40 (i.e. 19.51%) out of 205 answers was correct in the case of the invertible matrix.

In the following tables, "yes/no" means "the definition (exercise respectively) is correct/incorrect".

MATRIX RANK yes **186**				INVERTIBLE MATRIX yes **205**			
Linear dependence yes **67**		Linear dependence no 119		Linear dependence yes **71**		Linear dependence no 134	
Lin. comb. yes **41**	Lin. comb. no 26	Lin. comb. yes 29	Lin. comb. no 90	Lin. comb. yes **40**	Lin. comb. no 31	Lin. comb. yes 33	Lin. comb. no 101

Tab. 2: Definitions (matrix rank, invertible matrix)

In addition, 230 out of 300 tests included an exercise related either to linear dependence (100 students) or to matrix inversion (130 students). In these cases the relationship between the correctness of the solution of the exercise and the correctness of the formulation of relevant definition was examined. Considering this relationship, only the correctness of the solution procedure of the exercise (not numerical errors) was taken into account. The evaluation is in Table 3. The differences in data in Table 1 and Table 3 are given by the fact that the data in Table 1 are related to the total number 300 students, whereas the data in Table 3 are related to the total number 100 (in the case of linear dependence) or 130 (in the case of matrix inversion).

Evaluation of Tests in the Group B (The University of Economics in Prague)

The group B is the group of 230 students who expected the theoretical part in the test.

In the academic year 2010/2011, the task to formulate one given definition or theorem (not necessarily from linear algebra field) was mandatory in every mid-term test. It was impossible to incorporate more than one definition into the test, therefore it was not possible to make a direct comparison to the year 2009/2010 in all aspects. In order to make it possible to compare to the year 2009/2010, the relationship "knowledge of definition – correctness of the solution procedure of the exercise", exercises of the same type and definitions related to them as in 2009/2010 were given. The tests intended for comparison with the year 2009/2010 were administered by the same three teachers as in 2009/2010 to the same number of students taking the test allowing to compare the relationship between the definition and the exercise (i.e. to 230 students). The total number of tested students in the group B (230 students) was smaller than in the group A (300 students) and only the definitions of the terms linear dependence of vectors (100 students) and matrix inversion (130 students) were asked in the group B. The assessment criteria were the same in A as in B.

The number of correct answers and the evaluation of the relationship "knowledge of definition – correctness of the solution procedure of the exercise" are summarized in Table 3.

Results in the Groups *A* and *B*

Table 3 shows summary results in both groups A and B.

Students in the group A did not expect the theoretical part in the test – we can assume that they probably had not studied the theory. Students in group B expected the theoretical part in the test – we can assume that they had studied the theory. We are interested in how this fact is reflected in the results of tests – the level of dependence in each of pairs „the student can/cannot formulate the definition – the student can/cannot solve the exercise"; „the student can/cannot formulate the definition – the student did/did not expect the theory in test"; „the student can/

cannot solve the exercise – the student did/did not expect the theory" is studied.

	LINEAR DEPENDENCE				MATRIX INVERSION			
	A (in total 100)		*B* (in total 100)		*A* (in total 130)		*B* (in total 130)	
	number	%	number	%	number	%	number	%
Definition								
yes	36	36	42	42	43	33.08	88	67.69
no	64	64	58	58	87	66.92	42	32.31
Exercise								
yes	90	90	88	88	97	74.62	93	71.54
no	10	10	12	12	33	25.38	37	28.46
Def. – Ex.								
yes – yes	35	35	40	40	39	30	66	50.77
yes – no	1	1	2	2	4	3.08	22	16.92
no – yes	55	55	48	48	58	44.62	27	20.77
no – no	9	9	10	10	29	22.31	15	11.54

Tab. 3: Results in *A* and *B*

The results of the statistical evaluation by the log-linear models (in accordance with the notation above) are presented in the following tables. The first one shows the predicted counts in each category, the second table presents the fit of the model following (Agresti, 2002) in each of the two cases – linear dependence and matrix inversion. In logistic regression, the residual sum of squares is usually replaced by the deviance G^2 (Agresti, 2002). For two nested models, the difference in deviances has an asymptotic chi-squared distribution with degrees of freedom equal to the difference in the degrees of freedom for the two models. G^2 statistics is used to test the null hypothesis that the model holds against the saturated model. The bigger the value of G^2 (unbounded), the more we tend to reject the null hypothesis (i. e. the tested model). The quantity df is the degree of freedom and p-value is the probabilistic level on that the null hypothesis is (or is not) denied. The right column (delta) shows the dissimilarity index.

1) Linear dependence

Table 4 shows the predicted counts in each category, Table 5 presents the goodness of fit test and dissimilarity index (delta) of the models.

LINEAR DEPENDENCE							
	Definition	Exercise	Theory	Number	DE.DT. ET	DE.DT	DE.T
1	yes	yes	no	35	35	35	37
2	yes	no	no	1	1	1	2
3	no	yes	no	55	55	54	52
4	no	no	no	9	9	10	9
5	yes	yes	yes	40	40	40	37
6	yes	no	yes	2	2	2	2
7	no	yes	yes	48	48	49	52
8	no	no	yes	10	10	9	9

Tab. 4: The best models – linear dependence

	G^2	df	p-value	delta
fitDET	0.0	0	1.00000000	0.000
fitDE.DT.ET	0.1	1	0.81071295	0.004
fitDE.DT	0.4	2	0.80054144	0.014
fitDE.T	1.2	3	0.75249357	0.035

Tab. 5: Goodness of fit of the linear dependence model

Table 5 confirms that none of the tested models is denied at the 5% significance level.

All models DE.DT.ET, DE.DT and DE.T fit the data sufficiently well. The model DE.DT omits the insignificant ET pair, meaning that given level of D, E and T are independent. Thus the weakest relationship is in the pair ET – in the group of students having (or not having) the definition correct, the correctness of exercise is independent on study of the theory; i.e. the ability to solve exercises is independent on study of theory. The model DE.T shows that the strongest relationship is between D and E; i.e. the relationship between correctness of the definition and the exercise.

The odds ratio of DE was calculated from the model DE.T: let Dy, Dn denote „definition yes" (the definition was correct) and „definition no" (the definition was incorrect), analogically for the exercise Ey and En. Then (Dy/Dn)/(Ey/En) = exp(1.529) = 4.614, meaning that increasing the ratio Ey/En, the ratio Dy/Dn increases about 4.6 times. In other words, if the ratio of students having the exercise correct to students not having the exercise correct increases, the ratio of students having the definition correct to students not having the definition correct increases 4.6 times.

2) Matrix inversion

Table 6 shows the predicted counts in each category; Table 7 shows the goodness of fit test and dissimilarity index (delta) of the models.

MATRIX INVERSION							
	Definition	Exercise	Theory	number	DE.DT. ET	DE.DT	DE.T
1	yes	yes	no	39	37	34	31
2	yes	no	no	4	6	9	12
3	no	yes	no	58	60	57	64
4	no	no	no	29	27	30	23
5	yes	yes	yes	66	68	71	64
6	yes	no	yes	22	20	17	24
7	no	yes	yes	27	25	28	31
8	no	no	yes	15	17	14	11

Tab. 6: The best models – matrix inversion

	G^2	df	p-value	delta
fitDET	0.0	0	1.000000	0.000
fitDE.DT.ET	2.5	1	0.110956	0.038
fitDE.DT	5.0	2	0.080695	0.040
fitDT.E	11.8	3	0.008067	0.071

Tab. 7: Goodness of fit of the matrix inversion model

The models DE.DT.ET and DE.DT fit the data sufficiently. As in the case of linear dependence the conditional independence model DE.DT is the best among all conditional independence models (DE.DT, DE.ET, DT.ET); the weakest relationship is again in the pair ET. The remaining pairs DE and DT hold their (significantly) positive association and could not be omitted from the model without losing its statistical significance.

Although the joint independence model DT.E fits the data insufficiently, this model is the best among the other joint independent models. The relationship DT can be considered to be the strongest among the relationships DE, DT, ET.

The odds ratios of DT and DE were calculated from the model DE.DT (the best of the statistically significant models): let the meaning of Dy, Dn, Ey, En is as above, let Ty, Tn denote „theory yes" (the theory was expected) and „theory no" (the theory was not expected). Then (Dy/Dn)/(Ty/Tn) = exp(1.44) = 4.239 and the odds ratio of DE is (Dy/Dn)/(Ey/En) = exp(0.74) = 2.096.

This means that increasing the ratio Ty/Tn, the ratio Dy/Dn increases about four times. Similarly, increasing the ratio Ey/En, the ratio Dy/Dn doubles.

Evaluation of Tests in the Group C (The University of Finance and Administration)

In the academic year 2015/2016, a group of 90 students (the group *C*) of the University of Finance and Administration had the same task as the group *A* in the academic year 2009/2010 at the University of Economics in Prague (students did not expect the theoretical part in the credit test). The tests were administered and evaluated by the author of this article under the same conditions as in year 2009/2010.

Unlike the students of the University of Economics, the students of the University of Finance and Administration were exactly familiar with the structure of the credit test – they knew that the test would contain (among others) a task to calculate the rank of a matrix and determine the linear in/dependence of vectors. Almost all students have mastered these exercises (regardless of the numerical errors) – the percentage of failed students was negligible. For this reason the relationship between knowledge of definitions and the ability to solve exercises was not tested in this group. Students also knew that the test wouldn´t contain any exercise using matrix inversion – that is why students can be expected not to have studied this topic at all. As we can see in Table 8, the score corresponds to this expectations.

Table 8 shows the number of correct answers in group of 90 students of the University of Finance and Administration.

	number	%
linear combination	28	31.11%
linear dependence	39	43.33%
matrix rank	45	50%
invertible matrix	18	20%
matrix inversion	13	14.44%

Tab. 8: Success rate in formulating particular terms (the group *C*)

The success rate is significantly lower in the case of invertible matrix and matrix inversion in line with our expectations. As we can see by comparison with Table 1, this result is quite opposite to the result in the group *A* (for the reasons mentioned above).

The success rates in the groups *A* and *C* are compared by hypothesis testing (see (1) – (3)) at the 5% significance level for each of these terms. The results are summarized in Table 9.

	H_0	H_1	u	$W_{0.05}$
linear combination	$\pi_1 = \pi_2$	$\pi_1 \neq \pi_2$	- 0.019	$\lvert u \rvert \geq 1.960$
linear dependence	$\pi_1 = \pi_2$	$\pi_1 < \pi_2$	- 2.421	$u \leq$ - 1.645
matrix rank	$\pi_1 = \pi_2$	$\pi_1 > \pi_2$	2.032	u ≥ 1.645
invertible matrix	$\pi_1 = \pi_2$	$\pi_1 > \pi_2$	8.127	u ≥ 1.645
matrix inversion	$\pi_1 = \pi_2$	$\pi_1 > \pi_2$	3.204	u ≥ 1.645

Tab. 9: Hypothesis testing (comparison of the groups *A* and *C*)

In the case of linear combination, the calculated value of test criterion (u = - 0.019) lies outside the critical range $W_{0.05}$ – we do not reject the null hypothesis H_0: $\pi_1 = \pi_2$. The difference is not statistically proved at the 5% significance level and the similar success in both groups *A* and *C* cannot be excluded.

In the case of linear dependence, the calculated value of test criterion (u = - 2.421) lies in the critical range $W_{0.05}$ – we reject the null hypothesis in favor of the alternative hypothesis H_1: $\pi_1 < \pi_2$. It is statistically proved at the 5% significance level that students in the group *C* were more successful than students in the group *A.*

In the cases of matrix rank, invertible matrix and matrix inversion the calculated values of test criterion (u = 2.032, u = 8.127, u = 3.204, respectively) lie in the corresponding critical ranges $W_{0.05}$ – we reject the null hypothesis in favor of the alternative hypothesis H_1: $\pi_1 > \pi_2$. It is statistically proved at the 5% significance level that students in the group *A* were more successful than students in the group *C.*

As well as in the group *A,* the relationship between knowledge of the term rank of a matrix and invertible matrix, respectively, and the terms linear dependence and linear combination was examined. As we can see in Table 10, 45 students (out of 90 total) defined correctly the term rank of a matrix but only 15 (i.e. 33.33%) of them defined correctly the remaining terms. Only 9 (i.e. 50%) out of 18 answers was correct in the case of the invertible matrix.

MATRIX RANK yes **45**				INVERTIBLE MATRIX yes **18**			
Linear dependence yes **28**		Linear dependence no 17		Linear dependence yes **12**		Linear dependence no 6	
Lin. comb. yes **15**	Lin. comb. no 13	Lin. comb. yes 2	Lin. comb. no 15	Lin. comb. yes **9**	Lin. comb. no 3	Lin. comb. yes 0	Lin. comb. no 6

Tab. 10: Definitions (matrix rank, invertible matrix)

The success rates in the groups *A* (41 of 186, i.e. 22%) and *C* (15 of 45, i.e. 33.33%) are compared by hypothesis testing for the case of matrix rank. The null hypothesis H_0: $\pi_1 = \pi_2$ is tested at the 5% significance level against the alternative hypothesis H_1: $\pi_1 < \pi_2$. The calculated value of test criterion (u = - 1.586) lies outside the critical range $W_{0.05} = \{u;\ u \leq -1.645\}$ – the *alternative* hypothesis H_1: $\pi_1 < \pi_2$ cannot be accepted. It failed to statistically prove at the 5% significance level that students in the group *C* were more successful than students in the group *A*. However, it can be proved at the 10% significance level (even at the 6% level).

The number of correct answers is too low for statistical evaluation in the case of the invertible matrix.

Students in the group *C* seem to be able "to go to the root of the matter" better than students in the group *A*, but this fact is statistically proved only at the 10% significance level.

Most common errors

Most common errors were evaluated and compared in the groups *A* and *C*. In the case of definition of linear dependence and matrix inversion, also the results of the group *B* were taken in account.

The most common errors have the same character in all groups, regardless whether the students studied the theory or not. In general, in most cases the students were not able to formulate terms in generic way, struggled with generalized notation, ignored quantification, did not make any differences between definitions and theorems. Formulations often did not make any sense at all. The definitions correctly formulated by students

were very often formulated identically with wording and notation as in the textbook, in particular in groups *A* and *B*. Only in very sporadic cases the students managed to formulate the definition correctly in his/her own words.

Especially for each of tested definitions the most common errors are identical. Tables 11 - 15 show numbers of correct answers, most common errors, other errors and unanswered tasks (no attempt to formulate the definition). As we can see in these tables, the percentage of blank answers is much greater in the group *C* than in the group *A*. Except data in the tables, the number of most common wrong answers is related to the number of all incorrectly answered questions (except the blank answers). However, the low number of incorrect answers (and high number of blank answers) in the group *C* is not sufficiently conclusive in some cases for a statistical comparison of both groups in this respect. Nevertheless, the similarity of the character of most common error in both groups *A* and *C* is significant – not the fact that the percentage of these answers is higher or lower in the group *A* compared with the group *C*.

In the case of linear combination, the formulation of the sense "linear combination of the vectors are their multiples" is the most common error. Such formulation takes about 45% (49 of 108) of all wrong answers in the group *A* and 32% (8 of 25) in the group *C*. Detailed score is shown in Table 11.

Linear combination	*A*		*C*	
	number	%	number	%
correctly	93	31	28	31.11
multiple	49	16.33	8	8.89
other error	59	19.67	17	18.89
nothing	99	33	37	41.11
total	300	100	90	100

Tab. 11: Most common errors (linear combination)

In the case of linear dependence, the formulation of the sense "the vectors are linear dependent when one of these vectors is a multiple of some of others" is the most common error. Such formulation takes about 58% (102 of 175) of all wrong answers in the group *A* and 43% (10 of 23) in the group *C*. Detailed score is shown in Table 12.

Linear dependence	*A*		*C*	
	number	%	number	%
correctly	89	29.67	39	43.33
multiple	102	34	10	11.11
other error	73	24.33	13	14.44
nothing	36	12	28	31.11
total	300	100	90	100

Tab. 12: Most common errors (linear dependence)

In the case of matrix rank, the formulation of the sense "the rank of matrix is the number of (nonzero) rows" is the most common error. Such formulation takes about 64% (63 of 98) of all wrong answers in the group *A* and 80% (24 of 30) in the group *C*. Detailed score is shown in Table 13.

Matrix rank	*A*		*C*	
	number	%	number	%
correctly	186	62	45	50
nonzero rows	63	21	24	26.67
other error	35	11.67	6	6.67
nothing	16	5.33	15	16.67
total	300	100	90	100

Tab. 13: Most common errors (matrix rank)

In the case of invertible matrix, the statement "the matrix is invertible, if its determinant is nonzero" is the most common error (it is true, but in curriculum the definition is presented using rank of the matrix, not determinant – using a theorem instead of a definition is considered to be an mistake at the University of Economics). Such formulation takes about 46% (31 of 67) of all wrong answers in the group *A* and 43% (10 of 23) in the group *C*. Detailed score is shown in Table 14.

Invertible matrix	*A*		*C*	
	number	%	number	%
correctly	205	68.33	18	20
det A nonzero	31	10.33	10	11.11
other error	36	12	13	14.44
nothing	28	9.33	49	54.44
total	300	100	90	100

Tab. 14: Most common errors (invertible matrix)

In the case of matrix inversion, the most common errors are: a description of the procedure of the calculation and the formulation "invertible matrix is the matrix opposite to the given matrix" (without any specification). The first type of wrong formulation takes about 35% (55 of 157) of all wrong answers in the group *A* and 31% (13 of 42) in the group *C*, the second type takes about 22% (34 of 157) of all wrong answers in the group *A* and 45% (19 of 42) in the group *C*. Detailed score is shown in Table 15.

Matrix inversion	*A*		*C*	
	number	%	number	%
correctly	95	31.66	13	14.44
procedure	55	18.33	13	14.44
opposite	34	11.33	19	21.11
other error	68	22.67	10	11.11
nothing	48	16	35	38.89
total	300	100	90	100

Tab. 15: Most common errors (matrix inversion)

The even more detailed list of errors and numerous samples of formulations in the groups *A* and *B* are in Ulrychová (2013). Some remarks to the method of teaching the problematic terms are in Ulrychová (2013) and Ulrychová (2014).

Discussion

The results of the tests, their statistical evaluation and the analysis of the common errors lead to the following conclusions.

The statistical evaluation of results in the groups *A* and *B* gives an interesting result. One can expect the relationship between learning the theory and the correctness of the definition (DT) to be the strongest among the tested relationships (DT, DE, ET). In the case of matrix inversion, the result is in agreement with this expectation, but in the case of linear dependence, the relationship between correctness of the definition and the exercise is the strongest. That means that the level of students' general mathematical skills is more crucial than the study of the theory. That may be caused by the fact that students find the definition of linear dependence rather difficult to understand and formulate. On the other hand, the definition of matrix inversion is easy to understand and remember. This fact also corresponds with the results of the tests – the correctness of definition of matrix inversion doubled by learning the theory (from 33% to about 68%), whereas the correctness of definition of linear dependence increased much less (from 36% to 42%).

The statistical result in both cases (linear dependence and matrix

inversion) shows that the relationship ET is the weakest; i.e. the correctness of exercise does not depend on learning the theory. This means that the ability to solve exercises did not increase by learning the theory. The independence of the skills to solve exercises on the ability to formulate definitions is also confirmed by the results in the group *C*, in which almost all students solved right the exercises, but many of them did not even attempt to formulate definitions. On the other hand, the success rate of formulations of terms related to exercises that students had not expected in the test was even lower – it seems that the students may nevertheless have studied the theory when preparing for solving the exercises.

All the groups show the same character of the most common errors, irrespectively of whether students studied the theory or not and regardless of the type of the school. In particular, the most common errors are identical for each of the tested definitions.

However, the acquaintance of a definition still does not mean the knowledge of the matter. As shown in Table 2 and Table 10, the students formulated a given term correctly based on other terms, which they could not formulate correctly. The importance of such knowledge is then questionable.

There is a question: is it beneficial to ask students to formulate definitions exactly, when there is not enough time to practice it? For example, students can calculate the rank of matrix and use it for decision whether a system of linear equations has a solution or not – is it really necessary for students to be able to formulate the definition of rank of matrix and all terms related to? The teachers of specialized courses at universities of economic studies are generally consistent in the opinion that students should to master the calculus rather than theory. On the other hand, the teachers of mathematics are not consistent in this opinion.

There are some essential disadvantages of written form for testing the ability to formulate definitions and theorems. It is impossible to determine with certainty whether the student memorized the definition (without understanding it) or not. Moreover, the teacher cannot gradually correct the errors and help the student to reach the correct expression as in the case of oral examination. During the oral examination the teacher is able to differentiate if the student does not understand the term at all or if he/she has a pretty good understanding about the term but is just not able to express it. The latter case is certainly more beneficial than the case if the student just memorizes the terms without understanding them.

Although students' performance could among others depend on various factors – e.g. on the field of their study (Otavová and Sýkorová, 2015) or on the person of the teacher and his/her teaching methods (Majovská, 2015), (Milková and Kořínek, 2014), (Widenská, 2014), the errors, that the students make, have the same character independent on teacher and university (students of four teachers at two universities were tested). The analysis of most common errors can contribute to the improvement of the way of interpretation and practice (Matulová, 2015), if there is time for it.

Conclusion

In the case of the University of Economics in Prague with one-semester course of mathematics with a relatively wide curriculum, it is impossible to exercise the students to make them able to formulate mathematical terms precisely. The students solve this problem by memorizing definitions and they are not able to interpret results obtained by calculations. It is questionable whether in such case one should insist on precise wording of the definitions or to be satisfied at least with a general idea and to prefer the knowledge of relationships, the ability to make right conclusions and to interpret the results.

The approach to explaining the theory and namely to the oral examination is rather different at the University of Finance and Administration compared to the University of Economics. Interpreting the theory, the understanding is crucial and the exact formulations are not necessarily required from students during the oral examination – students can describe the essence in their own words with the possibility to correct themselves under the guidance of their examiner. Unfortunately, the low number of lessons does not allow students to practice the formulations of the definitions and theorems in the seminars. Another challenge is the high proportion of foreign students having difficulty speaking Czech. The rather less formal approach to teaching mathematics – compared to the University of Economics – did not yield better results in students' ability to formulate definitions, as shown above. However, according to students' poll, students appreciate this way of teaching and find it still difficult but more comprehensible.

Although the written form of testing of the ability to formulate definitions is not very appropriate for the abovementioned reasons, the most common errors are consistent with the author's experience during oral examinations at both universities (the University of Economics in Prague and the University of Finance and Administration). Also the statistical evaluation of the results of the tests is in accordance with teaching experience – the students' ability to solve exercises is often independent on study of the theory.

Students of universities of economic studies often do not accept the fact that in modern economics the position of mathematics is quite significant. This leads to their negative approach where they presume that mathematics is useless for their studies (Pražák, 2014). Teachers should try to change this approach – a comprehensible way of teaching should contribute to it. Based on the results presented in this article, it should be considered, to which extent the theory ought to be emphasized in mathematics courses at universities of economic studies. The main aim of the mathematical course at universities of economic studies is usually to make students able to use mathematical procedures for solving tasks in specialized courses. The fact that the students of these schools need primarily to master calculus rather than theory, definitely does not mean that the theory should not be taught at all. However the method of explaining the curriculum should be adequate to the specialization of the school and the teacher should consider the extent to which it is beneficial to ask students to formulate the definitions precisely (if there is no opportunity to practise it). On the other hand if the course provides enough time to practise correct formulations, students may benefit from it and apply them not only in the course of mathematics but also in other courses, as well as in their professional life (cf. Milková (2011)). Unfortunately, declining number of lessons of mathematics at some universities, as for example at the University of Economics in Prague (in detail in Ulrychová (2013)), does not allow to be much optimistic in this respect.

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COMPARISON OF THE TEST VARIANTS IN ENTRANCE EXAMINATIONS

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Highlight

- *Dependence of the test results on the test variants*

Abstract

The paper contains an analysis of the differences of number of points in the test in mathematics between test variants, which were used in the entrance examinations at the Faculty of Business Administration at University of Economics in Prague in 2015. The differences may arise due to the varying difficulty of variants for students, but also because of the different level of knowledge of students who write these variants. This problem we shall study in present paper. The aim of this paper is to study dependence of the results of entrance examinations in mathematics on test variants. The results obtained will be used for further improvement of the admission process at University of Economics.

Keywords

Entrance examinations, test variants, mathematics, statistical methods

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Introduction

Students of the Faculty of Business Administration are accepted to study on the basis of tests in mathematics and language tests. The math tests are prepared by the Department of Mathematics of the Faculty of Informatics and Statistics. These tests are the multiple choice question tests (Klůfa, 2012), (Zhao, 2006), (Klůfa, 2013), (Premadasa, 1993), (Klůfa, 2015b). Multiple choice question tests are suitable for entrance examinations at university. These tests are objective, results can be evaluated easily for large number of students. On the other hand, a student can obtain certain number of points in the test purely by guessing the right answers. This problem is addressed in education research Premadasa (1993), Zhao (2005, 2006) - the probabilistic analysis shows that the optimum number of choices of answers for the multiple choice question tests is four, and for a four-choice question test, increasing from 8 questions to 18 and 48 questions reduces the probability of obtaining a good result by pure guesswork from about 5% to below 1% and 0.01%, respectively. In Klůfa (2012) it was shown that risk of success of students with lower performance levels in entrance exams at University of Economics in Prague is negligible (approximately one student in million successfully makes the entrance exams by pure guessing the answers), i.e. the multiple choice question tests are optimal for admission process. The multiple choice question tests from probability point of view with similar results are also in Klůfa (2013).

The tests in mathematics at the Faculty of Business Administration at University of Economics in Prague have 10 questions for 5 points and 5 questions for 10 points, i.e. 100 points total. Questions are independent. Each question has 5 answers, one answer is correct, wrong answer is not penalized. The number of points in the test in mathematics can be: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45,..., 90, 95, 100. Test variants in mathematics are generated from a database created by the Department of Mathematics. Test variants, which were used in the entrance examinations at the Faculty of Business Administration at University of Economics in Prague in 2015 we can find in Klůfa and Langhamrová (2015), part of one of these variants is in Figure 2 in Appendix. The database of the Department of Mathematics is divided into more of the groups, e.g. goniometric equations, sequences etc. From the selected groups is generated a question. Finally, the generated variants are chosen which are used for entrance examinations. The effort is to choose variants, which are equally difficult for students.

The aim of this paper is to analyse the differences of number of points in the test in mathematics between test variants, which were used in the entrance examinations at the Faculty of Business Administration in 2015. Similar problems are solved in Brožová and Rydval (2013), Hrubý (2013), Kaspříková (2012), Mošna (2013), Klůfa (2015c), Kubanová and Linda (2012), Coufal and Tobíšek (2015), Otavová and Sýkorová (2014). The dependence of study results and results of the entrance exams in mathematics is solved in Kubanová and Linda (2012). Analogous problem (the dependence of study results in mathematics on ways of acceptance students at university) is analysed in Klůfa (2015c). From results of these papers follows that students should be accepted to study on the basis of own admission process. University study results as related to the admission exam results we can find also in Kučera, Svatošová and Pelikán (2015). Analysis of the study results in basic courses in mathematics at University of Economics is in Kaspříková (2012) and Otavová and Sýkorová (2014). There is studied whether the score from final test depends on the score from mid-term test. Obtained results show that dependence between the score from final test and the score from mid-term test exists. The exam results in mathematics at Czech University of Life Sciences in Prague from the last 13 years have been analysed in Brožová and Rydval (2013). The reasons of low grades of students are discussed in this paper. Mathematics is generally said to be one of the unpopular school subjects. Popularization

of mathematics (e-learning) is described in Coufal and Tobíšek (2015). E-learning and teaching of mathematics is also in Mošna (2013).

The differences between test variants may arise due to the varying difficulty of variants, but also because of the different level of knowledge of students who write these variants. This problem we shall study in present paper. The results obtained will be used to further improve of the preparation of test variants in coming years.

This paper is an extended version of the paper Klůfa (2016) – results of other group of students, obtained in project "Entrance exams practice" in 2016, was analyzed.

Material and Methods

The analysed data are the results of the entrance examinations of 1514 students in mathematics at the Faculty of Business Administration in 2015. Six test variants, denoted A0, A8, A9, B0, B4, B6, were used for the entrance examinations in mathematics at the Faculty of Business Administration in 2015, other test variants were not used at this faculty. Differences between genders are not analysed in present paper.

On the other hand, the Department of Mathematics organizes preparatory courses for entrance examinations in mathematics. The results of one randomly selected parallel class (17 students) of these courses in 2016 will be analysed in this paper as well.

Furthermore, other results of 58 students, which were obtained in project "Entrance exams practice" in 2016, will be analysed in present paper.

For study the differences of number of points in the test in mathematics between 2 test variants we shall use paired t-test and t-test for independent samples. Statistic t for paired test is

$$t = \frac{\overline{d}}{s_d}\sqrt{n}, \tag{1}$$

where $d_i = x_i - y_i$, and x_i, y_i is number of points in the test in mathematics of a student i in 1st and 2nd test variant, $\overline{d}$ is average of values d_i, s_d is standard deviation, n is sample size (17). When

$$|t| > t_\alpha(n-1), \tag{2}$$

where $t_\alpha(n-1)$ is critical value of student t distribution with $(n-1)$ degrees of freedom, the hypothesis "mean number of points in 2 test variants is the same" is rejected at significance level α.

Statistic t for t-test for independent samples (under the same variance of samples) is

$$t = \frac{\overline{x} - \overline{y}}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}, \tag{3}$$

where $\overline{x}, \overline{y}$ is average number of points in the test in mathematics in 1st and 2nd sample, n_1, n_2 is sample size in 1st and 2nd sample (in our case is $n_1 = n_2 = 29$) and s is standard deviation (s_x, s_y is standard deviations in 1st and 2nd sample) given by relation

$$s = \sqrt{\frac{1}{n_1+n_2-2}[(n_1-1)s_x^{\,2} + (n_2-1)s_y^{\,2}}. \tag{4}$$

When

$$|t| > t_\alpha(n_1+n_2-2), \tag{5}$$

where $t_\alpha(n_1+n_2-2)$ is critical value of student t distribution with (n_1+n_2-2) degrees of freedom, the hypothesis "mean number of points in 2 test variants is the same" is rejected at significance level α.

For comparison of 6 test variants at the Faculty of Business Administration in 2015 we shall use ANOVA and Scheffé's method. We shall verify the validity of the null hypothesis: mean number of points in test variants A0, A8, A9, B0, B4, B6 is the same. When the test statistic (Rao, 1973)

$$F > F_\alpha(k-1, n-k), \tag{6}$$

where $F_\alpha(k-1, n-k)$ is critical value of Fischer-Snedecor distribution with $(k-1)$ and $(n-k)$ degrees of freedom, the hypothesis is rejected at significance level α. In our case is $k = 6$ (number of variants) and $n = 1514$ (sample size for ANOVA).

Results

Differences between the test variants

The results of the entrance examinations of 1514 students in mathematics at the Faculty of Business Administration in 2015 are in Table 8, Table 9, Table 10, Table 11, Table 12, Table 13 in Appendix. Now we shall compare distributions of number of points in the test in mathematics in test variants A0, A8, A9, B0, B4, B6 - see Figure 1 and Table 1.

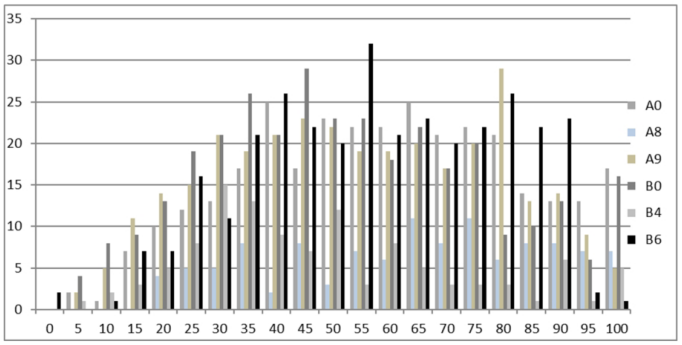

Figure 1: Distribution of number of points in test in mathematics in 2015 – test variants A0, A8, A9, B0, B4, B6 (histogram) (source: own calculation)

Test variant	Frequency n_i	Average number of points	Variance
A0	317	59.23	543.94
A8	114	64.17	540.23
A9	318	54.61	559.70
B0	327	52.54	584.03
B4	113	47.92	544.97
B6	325	57.31	462.71

Table 1: Distribution of number of points in test – test variants A0, A8, A9, B0, B4, B6 (source: own calculation)

We shall test null hypothesis "the differences between average number of points in test variants A0, A8, A9, B0, B4, B6 in Table 1 are not statistically significant".

To verify the validity of the hypothesis we use ANOVA. In the first step we verify assumption of this method by Bartlett's test, i.e. we verify the hypothesis "variance of number of points in test variants A0, A8, A9, B0, B4, B6 is the same". Test statistic B (see e.g. Anděl (1978)) is $B = 4.9$. Critical value of χ^2 distribution for 5 degrees of freedom and significance level $\alpha = 0.05$ is $\chi^2_{0.05}(5) = 11.1$. Since $B < 11.1$, the hypothesis "variance of number of points in test variants A0, A8, A9, B0, B4, B6 is the same" is not rejected at 5% significance level, assumption of ANOVA can be considered to have been met.

Source of variability	Sum of Squares	Degrees of freedom	Fraction	F	p value	F crit
Test variants	23365.02	5	4673.00	8.68	3.99E-08	2.22
Residual	811706.13	1508	538.27			
Sum	835071.15	1513				

Table 2: Results of ANOVA (source: own calculation)

Results of ANOVA we got with MS Excel (Marek, 2013) – see Table 2. Since

$$F = 8.68 > 2.22,$$

the null hypothesis is rejected at 5% significance level. There are some differences between the test variants, the differences between average number of points in test variants A0, A8, A9, B0, B4, B6 in Table 1 are statistically significant.

Finally we shall study which pairs of averages differ significantly. We use Scheffé's method (Anděl, 1978). Pairs of averages differ significantly if absolute value of difference in averages exceeds critical value

$$\sqrt{(\tfrac{1}{n_i} + \tfrac{1}{n_j})\ x\ 5\ x\ 538.27\ x\ 2.22} \qquad (7)$$

where 538.27 is the residual variance and 2.22 is the critical value from Table 2.

Test variant	A0	A8	A9	B0	B4	B6
A0		4.94	4.62	6.69	11.31*	1.92
A8			9.56*	11.63*	16.25*	6.86
A9				2.07	6.69	2.70
B0					4.62	4.77
B4						9.39*
B6						

**Significant difference for α=0.05 (Scheffé's method)*

Table 3: Absolute value of differences between average number of points in test variants A0, A8, A9, B0, B4, B6 (source: own calculation)

From Table 3 it is seen that a significant difference is at 5% significant level between A0 and B4, A8 and A9, A8 and B0, A8 and B4, B4 and B6. All other pairs of averages are not significantly different. Greatest significant difference is between the test variants A8 and B4.

Difference between A8 and B4 – paired t test

Significant differences between test variants may arise due to the varying difficulty of variants for students, but also because of the different level of knowledge of students who write these variants. Therefore we shall now study results of the same group of students – see results of 17 students in preparatory course for entrance examinations in 2016 in Table 4.

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A8	100	60	70	35	40	25	40	60	55	45	60	55	45	70	45	55	80
B4	95	45	80	20	35	20	45	50	50	50	55	60	45	80	40	40	85
d_i	5	15	-10	15	5	5	-5	10	5	-5	5	-5	0	-10	5	15	-5

Table 4: Number of points in mathematics in test variants A8 and B4 (source: own calculation)

From Table 4 we have average number of points in mathematics in test variants A8 $\bar{x}_{A8} = 55.29$ and average number of points in mathematics in test variants B4 $\bar{x}_{B4} = 52.65$.

Now we shall test null hypothesis "the difference between these average number of points in test variants A8, B4 is not statistically significant".

We have two results for the same student. It means that the samples in Table 4 are not independent. Therefore, to verify the validity of the hypothesis we use paired t test. According to (1) we have

$$t = 1.31$$

Critical value of t distribution for 16 degrees of freedom and significance level $\alpha = 0.05$ is $t_{0.05}(16) = 2.12$. Since

$$|t| < 2.12,$$

the null hypothesis is not rejected at 5% significance level. Because $t_{0.20}(16) = 1.34$, this hypothesis is not rejected also at 20% significance level. The difference between average number of points in test variants A8 and B4 in preparatory course for entrance examinations in 2016 is not statistically significant.

Difference between A8 and B4 – t test for independent samples

Now we shall compare other results of 58 students, which were obtained in project "Entrance exams practice" in 2016

(two different groups of students, each group has 29 students, i.e. $n_1 = n_2 = 29$). These students wrote test variants A8 and B4 once more, results are in Table 14 in Appendix, descriptive statistics for distributions of number of points in the test in mathematics in test variants A8 and B4 are in Table 5.

Test variant	A8	B4
Average number of points	47.931	40.517
Median	45	30
Modus	15	25
Variance	588.42	572.04
Kurtosis	-0.854	-0.616
Skewness	0.181	0.714

Table 5: Descriptive statistics for number of points in mathematics in test variants A8 and B4 (source: own calculation)

From Table 5 we have average number of points in mathematics in test variants A8 $\bar{x}_{A8} = 47.93$ and average number of points in mathematics in test variants B4 $\bar{x}_{B4} = 40.52$.

Now we shall test null hypothesis "the difference between these average number of points in test variants A8, B4 is not statistically significant".

We have results of two different groups of students, i.e. the results are independent. Therefore, to verify the validity of the hypothesis we use t-test for independent samples. In the first step we verify assumption of the same variance of samples by Fisher-Snedecor F-test. The hypothesis "variance of number of points in test variants A8 and B4 is the same" is not rejected at 5% significance level (p-value is 0.47), assumption of the t-test for independent samples can be considered to have been met.

Results of the t-test for independent samples we got with MS Excel (Marek, 2013) – see Table 6. According to (3) we have

$$t = 1.172$$

Critical value of t distribution for 56 degrees of freedom and significance level $\alpha = 0.05$ is $t_{0.05}(56) = 2.003$. Since

$$|t| < 2.003,$$

the null hypothesis is not rejected at 5% significance level. Because p-value is 0.246 (see Table 6), this hypothesis is not rejected also at 24% significance level. The difference between average number of points in test variants A8 and B4 in project "Entrance exams practice" in 2016 is not statistically significant.

Alfa=0.05	A8	B4
Average	47.931	40.517
Variance	588.42	572.04
Sample size	29	29
Standard deviation (see (4))	24.088	
Degrees of freedom	56	
t Stat	1.172	
p- value	0.246	
Critical value	2.003	

Table 6: Results of the t-test for independent samples (source: own calculation)

Discussion

From results of this paper it follows that the difference between average number of points in mathematics in test variants A8 and B4 in entrance exams in 2015 is statistical significant – see also second row of Table 7. Therefore, we ask whether these test variants are equally difficult for students.

Test variant	A8	B4
2 different groups of students in entrance exams in 2015	$\bar{x}_{A8} = 64.17$	$\bar{x}_{B4} = 47.92$
1 group of students in preparatory course in 2016	$\bar{x}_{A8} = 55.29$	$\bar{x}_{B4} = 52.65$
2 different groups of students in project "Entrance exams practice" in 2016	$\bar{x}_{A8} = 47.93$	$\bar{x}_{B4} = 40.52$

Table 7: Average number of points in mathematics (source: own calculation)

For the same group of students in preparatory course in 2016 the difference between average number of points in mathematics in test variants A8 and B4 is not statistical significant – see also third row of Table 7. For two different groups of students in project "Entrance exams practice" in 2016 the difference between average number of points in mathematics in test variants A8 and B4 is not statistical significant, either. It means that the difference between test variants A8 and B4 in entrance exams in 2015 could be caused by other factors, e. g. by the different level of knowledge of students who wrote these variants in entrance exams in 2015.

Entrance exams in mathematics at the University of Defence in Brno with similar problems are analysed in Hošková-Majerová and Račková (2010) - examples in mathematics with the same level of difficulty. Analysis of the entrance examination in mathematics at University of Pardubice we can find in Linda and Kubanová (2013) – correlation between results of the entrance examination test in mathematics and examination in mathematics at the university. The aim of these papers was a little different. Analysis of the entrance tests in mathematics at Faculty of mathematics, physics and informatics at Comenius University in Bratislava we can find in Kohanová (2012). The focus of the paper is to find what types of tasks should be included in the entrance test if we want to select students who have best predispositions for study. Similar statistical methods here were used as in present paper.

The problem of the same difficulty of tests variants in entrance examination, which is mentioned in this paper, occurs in scientific papers only rarely. One of them is paper written by Klůfa (2015a). There is on the basis of test of independence in contingency table shown that results of entrance examinations at the Faculty of Informatics and Statistics at University of Economics in Prague do not depend on the test variants, i.e. the analogous result as in present paper.

Conclusion

The differences between average number of points in mathematics in test variants A0, A8, A9, B0, B4, B6, which were used for the entrance examinations in mathematics at the Faculty of Business Administration in 2015, are statistically significant. The differences may arise due to the varying difficulty of variants, but also because of the different level of knowledge of students who write these variants. From results of this paper it follows that these significant differences between tests variants may arise due to different level of knowledge of

the students who wrote these variants. On the other hand, the difficulty of test variants for students is poorly measured. This problem will be solved in the following paper.

Significant changes in test variants in mathematics in the coming years are not needed. But increase the homogeneity test variants would be very useful. Therefore the database created by the Department of Mathematics will be further modified - the database will be expanded and divided into more of the groups.

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Appendix

Number of points in test in mathematics in 2015 – test variant A0
60 65 20 75 60 25 75 65 25 5 90 70 20 60 60 100 85 40 95 100 60 30 30 90 50 90 70 35 40 75 70 60 55 30 55 75 70 20 60 35 55 60 85 65 60 70 50 55 20 50 100 15 80 35 80 85 35 65 30 60 25 80 70 100 55 50 5 50 80 40 50 55 40 60 75 95 40 75 30 25 55 35 80 80 80 45 45 55 35 70 35 85 40 20 75 65 100 45 85 50 75 55 20 70 55 50 45 100 65 25 65 75 55 15 35 30 70 45 35 45 75 25 95 65 80 45 50 95 40 15 40 40 55 65 40 35 20 100 70 80 20 35 90 70 55 45 45 25 25 45 80 100 100 75 60 90 70 45 65 85 40 75 15 80 55 55 80 70 75 90 20 65 90 55 45 65 55 65 65 60 25 65 30 20 35 85 50 50 60 100 80 80 65 80 35 40 75 75 50 55 75 90 90 60 85 80 50 65 70 50 35 60 30 50 45 45 50 95 45 40 30 10 50 55 70 40 60 40 80 30 40 60 35 75 70 40 15 55 40 50 40 25 45 80 85 40 70 30 55 40 55 15 75 90 45 30 70 40 60 35 15 50 30 50 40 35 60 70 50 75 60 75 85 65 65 85 65 75 25 65 95 100 90 95 65 85 85 25 100 100 80 70 100 100 95 60 90 40 85 95 95 65 65 100 50 90 80 70 75 95 100 95 95 40 65 50 80

Table 8: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Number of points in test in mathematics in 2015 – test variant A8
70 95 95 75 45 45 65 50 25 90 90 20 60 55 75 35 40 45 45 55 60 75 85 30 20 50 80 70 65 45 65 75 85 55 65 65 60 85 70 100 70 55 60 50 35 80 75 75 70 70 40 55 30 80 55 100 25 35 35 85 30 65 65 75 35 35 65 60 75 80 80 45 100 75 20 25 90 90 65 90 100 85 45 20 25 35 35 30 45 90 85 30 75 60 95 65 80 55 25 70 95 75 95 95 70 90 95 85 100 100 100 65 90 85

Table 9: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Number of points in test in mathematics in 2015 – test variant A9
85 20 30 50 75 45 25 65 25 70 50 65 85 20 80 80 35 35 15 25 95 45 35 80 20 45 65 65 40 40 45 35 70 30 65 35 25 80 50 40 85 40 75 10 45 50 20 65 70 60 45 40 50 45 65 25 70 70 30 75 75 65 30 40 75 80 40 45 45 70 10 30 40 40 70 90 45 95 15 80 80 80 65 30 55 80 55 35 55 50 40 70 25 30 95 95 70 75 75 15 10 40 60 90 35 30 20 90 55 50 55 50 20 35 85 70 10 30 70 65 60 30 90 35 35 65 5 15 40 15 5 60 75 10 45 55 15 50 30 20 70 75 40 75 20 80 30 25 20 15 40 60 50 35 90 50 45 35 90 90 75 25 50 30 75 60 45 60 80 80 80 40 90 40 50 25 50 70 25 85 60 20 60 35 25 50 50 85 65 35 80 25 40 85 40 45 70 70 55 95 60 65 80 65 30 35 20 25 55 40 45 55 95 45 85 35 55 55 45 35 30 75 50 50 60 40 70 20 20 80 45 45 50 35 55 60 60 15 65 55 15 30 25 60 20 30 60 30 50 30 80 40 45 15 80 60 55 80 90 45 50 85 75 80 75 75 60 30 30 15 75 80 80 80 55 75 75 80 80 65 80 80 80 90 45 65 25 85 60 90 45 95 80 35 70 90 55 50 100 75 100 95 65 90 100 55 85 65 65 100 55 90 60 95 55 100 85 85

Table 10: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Number of points in test in mathematics in 2015 – test variant B0
40 55 90 40 35 95 15 10 65 45 50 65 90 55 50 20 65 45 25 15 30 50 75 50 30 45 70 45 25 30 50 10 90 10 40 65 60 55 20 25 60 60 35 20 100 15 35 100 20 30 40 35 35 75 5 40 25 60 85 90 45 15 65 40 50 25 30 35 35 45 65 60 45 45 65 5 60 65 45 55 80 30 65 30 45 40 75 85 15 65 95 45 95 45 40 35 80 75 15 95 50 75 40 40 30 35 80 75 15 90 50 30 55 65 65 35 35 80 25 20 65 55 45 25 70 5 35 100 20 75 60 10 40 35 35 30 70 45 90 60 35 90 70 75 35 100 70 75 100 80 30 35 45 70 40 65 65 10 75 40 60 30 40 20 55 90 75 60 30 25 35 50 20 55 40 75 50 75 65 45 15 70 35 65 85 90 50 55 35 100 25 55 10 55 45 30 25 35 70 30 90 15 60 20 75 95 40 70 80 75 65 65 55 70 45 50 70 55 65 45 35 25 55 10 25 50 90 50 25 60 50 65 50 25 85 55 55 45 75 45 25 45 35 20 35 40 20 60 20 50 60 35 50 25 30 65 70 5 85 10 45 55 45 60 30 45 40 55 60 45 25 30 70 55 30 25 40 40 85 40 50 50 20 75 55 55 70 60 45 55 55 100 70 100 50 95 100 90 35 85 100 30 85 100 50 85 75 100 80 100 100 70 45 80 100 80 30 50 75 100 90 85 75 60 25 70 45

Table 11: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Number of points in test in mathematics in 2015 – test variant B4
30 30 30 80 60 25 40 40 45 45 30 60 50 60 65 30 15 20 50 40 70 30 30 65 35 40 55 25 40 25 30 40 30 25 20 30 90 40 5 25 45 60 35 35 45 35 25 30 35 20 50 100 20 50 40 50 30 55 35 30 35 10 50 80 40 20 15 65 50 70 60 35 25 55 45 60 15 35 65 50 70 60 45 10 75 45 50 30 35 25 30 35 35 90 90 50 60 75 80 100 85 50 90 100 50 100 95 90 90 35 65 100 75

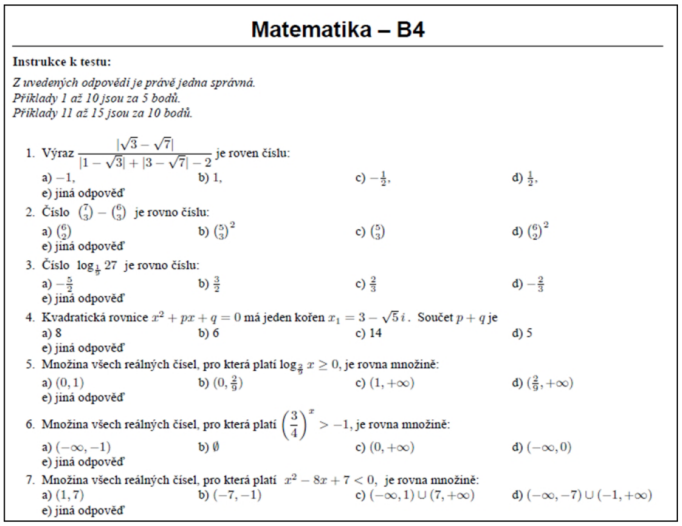
Table 12: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Number of points in test in mathematics in 2015 – test variant B6
80 45 55 70 85 60 50 65 45 30 90 50 70 70 25 45 55 60 90 85 85 35 40 65 60 70 65 100 35 55 30 75 65 0 40 35 65 20 55 40 20 50 80 65 35 80 45 80 65 80 85 85 30 80 65 45 60 55 35 50 25 55 20 60 35 45 15 70 70 25 25 55 75 50 40 75 40 90 80 50 40 75 75 80 75 35 90 55 40 80 75 65 90 15 90 90 60 50 30 30 25 80 65 40 30 30 75 35 50 35 45 75 60 55 70 0 20 65 70 60 30 35 65 75 90 25 35 30 35 50 25 40 50 60 25 45 75 45 75 85 60 45 70 35 85 60 40 40 70 25 35 85 60 50 80 90 50 55 40 20 70 40 40 55 40 35 65 70 75 80 60 40 65 55 90 35 60 55 50 65 15 40 50 50 55 45 30 60 45 75 55 55 40 85 45 55 55 35 40 25 10 35 60 55 75 70 75 50 25 55 30 80 45 80 20 40 25 70 25 65 80 45 55 75 85 55 90 85 50 90 40 70 15 55 75 65 80 65 55 45 40 55 20 45 85 60 40 70 55 65 80 80 50 45 65 35 55 15 65 40 75 80 40 25 55 85 90 70 45 60 55 65 70 15 40 75 80 95 50 55 90 25 85 60 45 85 90 50 85 60 45 85 90 85 90 85 25 75 80 80 75 90 60 80 90 90 45 85 35 95 90 80 15 55 90 70 80 85 65 70 80 55 90 35 85

Table 13: Results of the entrance examinations in mathematics at the Faculty of Business Administration in 2015 (source: own data)

Test variant	Number of points in test in mathematics in 2016
A8	15 70 65 45 20 20 30 100 85 40 80 45 15 20 50 55 60 15 80 45 70 70 45 50 60 15 65 40 20
B4	50 5 25 25 35 40 45 30 25 75 70 25 25 15 30 15 30 55 90 75 40 85 25 80 20 10 35 30 65

Table 14: Results obtained in project "Entrance exams practice" in 2016 (source: own data)



Matematika – B4

Instrukce k testu:

Z uvedených odpovědí je právě jedna správná.
Příklady 1 až 10 jsou za 5 bodů.
Příklady 11 až 15 jsou za 10 bodů.

1. Výraz $\frac{|\sqrt{3}-\sqrt{7}|}{|1-\sqrt{3}|+|3-\sqrt{7}|-2}$ je roven číslu:
   a) -1, b) 1, c) $-\frac{1}{2}$, d) $\frac{1}{2}$, e) jiná odpověď
2. Číslo $\binom{7}{4}-\binom{6}{3}$ je rovno číslu:
   a) $\binom{6}{2}$ b) $\binom{5}{3}^2$ c) $\binom{5}{3}$ d) $\binom{6}{2}^2$ e) jiná odpověď
3. Číslo $\log_{\frac{1}{3}} 27$ je rovno číslu:
   a) $-\frac{5}{2}$ b) $\frac{3}{2}$ c) $\frac{2}{3}$ d) $-\frac{2}{3}$ e) jiná odpověď
4. Kvadratická rovnice $x^2+px+q=0$ má jeden kořen $x_1=3-\sqrt{5}\,i$. Součet $p+q$ je
   a) 8 b) 6 c) 14 d) 5 e) jiná odpověď
5. Množina všech reálných čísel, pro která platí $\log_{\frac{2}{9}} x \geq 0$, je rovna množině:
   a) $(0,1)$ b) $(0,\frac{2}{9})$ c) $(1,+\infty)$ d) $(\frac{2}{9},+\infty)$ e) jiná odpověď
6. Množina všech reálných čísel, pro která platí $\left(\frac{3}{4}\right)^x > -1$, je rovna množině:
   a) $(-\infty,-1)$ b) $\emptyset$ c) $(0,+\infty)$ d) $(-\infty,0)$ e) jiná odpověď
7. Množina všech reálných čísel, pro která platí $x^2-8x+7<0$, je rovna množině:
   a) $(1,7)$ b) $(-7,-1)$ c) $(-\infty,1)\cup(7,+\infty)$ d) $(-\infty,-7)\cup(-1,+\infty)$ e) jiná odpověď

Figure 2: Part of the test variant B4 in mathematics in 2015 (source: own construction)

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