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CONTENT

APPROACHES TO EMPLOYEE DEVELOPMENT IN CZECH ORGANISATIONS
Lucie Vnoučková, Hana Urbancová, Helena Smolová 1

THE SUBJECT OF STATISTICS IN NATURAL SCIENCE CURRICULA: A CASE STUDY
Aneta Hybšová, Jimmie Leppink 8

IMPACT OF HEURISTIC STRATEGIES ON PUPILS' ATTITUDES TO PROBLEM SOLVING
Jarmila Novotná, Petr Eisenmann, Jiří Přibyl 15

ANALYSIS OF DEPENDENCES OF E-LEARNING USAGE ON STUDY RESULTS
Martina Kuncová, Hana Vojáčková 24

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EDITORIAL

EDITORIAL

Journal on Efficiency and Responsibility in Education and Science (ERIES Journal) has started the year 2015 with many positive changes and follows the trend of increasing its quality.

Firstly, we are glad to announce that we have extended the Editorial board team. Dr. José Antonio Rodriguez Arroyo from the Monterrey Institute of Technology in Mexico, Assoc. Prof. Anna Croon Fors from Umea University in Sweden, Ing. Jaromír Novák, Ph.D. from University of Economics in Bratislava, Slovakia, and prof. RNDr. Libor Pavera, CSc. from University of Economics in Prague, Czech Republic are the new members of the Editorial Board. We are convinced that all of them will contribute to a higher quality of the ERIES Journal.

Secondly, the ERIES Journal is currently indexed in the Directory of Abstract Indexing for Journals (DAIJ). We all hope that the wider indexation of the ERIES Journal will help to address published articles to more readers in more countries. As a result, apart from the DAIJ indexation, the ERIES Journal is also indexed in the EBSCO database, the Directory of Open Access Journals, the List of reviewed periodicals in the Czech Republic. We are committed to extend the indexation of the ERIES journal to other databases during this year.

In this first issue of the year 2015, we have variety of articles from the University of Economics and Management in Prague; Charles University in Prague, and College of Polytechnics in Jihlava. The articles deal with employee development, incorporating statistics in the university curriculum, heuristic strategies for problem solving, and dependence of e-learning on study results.

Authors Lucie Vnoučková, Hana Urbancová and Helena Smolová evaluate possibilities of employee education and development in the Czech organizations. The authors also try to identify main approaches to employee development. For this purpose, a quantitative analysis is carried out for responses of 125 employees from small, medium and large organizations. The results, on the one hand, show that 70% of respondents have possibility of development and 63% stated that employer supports their development. On the other hand, responses indicate that 27% of respondents do not feel any possibility to grow, which leads to disaffection, loss of production or to employee turnover.

Aneta Hybšová and Jimmie Leppink discuss a role and a position of statistics in a university curriculum with regard to following questions: *how to integrate statistics in curriculum*, *which topics to cover and in what detail*, *how much time to allocate to statistics*, and *how to organize courses and which study materials to select*. Four curricula at Charles University in Prague are compared to address these questions. The authors conclude the article with guidelines for designing a statistics curriculum.

Jarmila Novotná, Petr Eisenmann and Jiří Přibyl focus on heuristic strategies convenient for improvement of pupils´ culture of problem solving. The authors analyse the impact of heuristic strategies *Introduction of an auxiliary element* and *Omitting a condition*. The authors conducted 11 teaching experiments in 11 lower and upper secondary schools in the North Bohemia between yeas 2012 and 2013. Results of the experiment indicate that, unlike in the case of the strategy Introduction of an auxiliary element, successful use of the strategy Omitting a condition requires longer teacher's work with the pupils.

In the last article of this first issue, the authors Martina Kuncová and Hana Vojáčková analyse study results of selected subject of a full-time and part-time forms of study. Six subjects are analysed with regard to an implementation of e-learning platform. The analysis is carried out for the years 2008, 2010 and 2012. Although the results show differences in study results between full-time and part-time students, the authors cannot prove the influence of the e-learning implementation.

We hope that all our readers will find this first issue of the year 2015 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. We are also grateful to all the authors and reviewers who contributed in this first issue in 2015.

Sincerely,

prof. RNDr. Jaroslav Havlíček, CSc.
Editor-in-Chief
ERIES Journal

APPROACHES TO EMPLOYEE DEVELOPMENT IN CZECH ORGANISATIONS

Lucie Vnoučková[1], Hana Urbancová[2], Helena Smolová[1]

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Highlights

- *Research outcomes identified types of employee development programmes of organisational learning*
- *Approaches to employee development in Czech organisations are described*

Abstract

Education, development, knowledge management, career development and talent management are currently often discussed themes regarding strategic management of organisations. Those concepts are strategically important. Therefore the aim of the article is to evaluate possibilities of employee education and development and identifies main approaches to employee development in Czech organizations. The results are based on a quantitative survey by questionnaire data collection. The results shows that 70% of respondents have possibility of development; 86 % uses their skills and abilities and 63 % stated that their employer support their development. On the contrary, 27 % do not feel any possibility to grow and that may lead to disaffection, loss of production or even to employee turnover. Based on the results of the analysis, employees, who miss adequate level of development are usually key and knowledge employees; it is necessary to support their career plans and development to retain them in organisation.

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Introduction

Constant change in the external environment and the implementation of new trends in business requires that organizations adapt to new conditions, and that they respond to them appropriately. Human Resources Management is one of the most complex and most important areas on which an organisation must focus (Thomson, 2007). Successful organizations therefore have one common factor: quality employees. For an organization it is important to acquire and retain talented employees who can become a key competitive advantage Talent is often defined as natural ability to do something well, and Hroník (2007) adds that at present the criteria for talent are respect, productivity, and perspective – not age, as was thought previously. Each organization may have its own criteria when selecting talent according to which talent is sought and identified (Morongová, Urbancová, 2014). Talent management may be considered as a proper tool for applying and retaining talented employees, and which consists of three activities, the recruitment, development, and retention of these workers, and yet it is necessary that they are motivated to work, that they consider their work stimulating and interesting, that they may have and feeling of personal success and, last but not least, that they may find in it an opportunity for personal development. All of these factors and many others influence the resulting loyalty of the worker to the organization in which they work.

This article aims to evaluate possibilities of employee education and development and identifies main approaches to employee development in Czech organizations. The paper is composed of five sections. The first is Introduction, the second one is Theoretical Background, this followed by a presentation of the methodological approach. Subsequently, an analysis and discussion section comes before the recommendations. Finally, authors conclude the paper and summarize the contributions and limitations of the article.

Theoretical Background

According to probably one of the most commonly cited definitions, human resources management may be characterised as strategically and logically engineered approach which serves for the management of an organization's most valuable asset – its people (Armstrong, 2007, p. 27). Employee development can also be defined as *"development of the qualitative aspects of the interorganizational work force*." (Dvořáková, 2004, p. 106), whereas this change may applies for example to qualifications, personal potential, capability, as well as health or lifestyle (Bělohlávek, 2008).

It is possible to include employee safety (future certainty and also safety on workplace), compensation, management of mutual relationships and employee development. This is one of the most important functions of human resources management (Hameed and Waheed, 2011). From the results of numerous studies it can be concluded that practices applied as part of human resources management significantly influence the behaviour and attitudes of employees (Muse and Stamper, 2007; Edgar and Geare, 2005). Employee development should therefore be part of the overall strategy of an organization (or its policies) (Kocianová, 2010, p. 169; Drucker, 2000), as over the long term it can be considered an indisputable competitive advantage (Stýblo, 2008, p. 81). For this reason nowadays in particular and number of companies focus on employee development with a certainly regular periodicity (Useem, 1993; Kavita and Diksha, 2014).

In association with the issues under analysis it is also important to specify certain differing terms:

- Development – achieving the desired changes through learning. This is more generally focussed, and takes as its goal the "training" of the employee with variable knowledge, skills, and attitudes that can later be used in his personal growth (Bedrnová, Nový and Jarošová, 2012, p. 192).
- Learning – the process of change. An active practice of the trainee that consists of the quantitative and qualitative growth of adopted knowledge, but also the transfer and potential changes of values, attitudes, interests, and other elements focussed on human development (Veteška and Tureckiová, 2008).
- Education – one of the methods of learning and process of acquiring and adopting knowledge from various spheres of human awareness (Vodák and Kucharčíková, 2011).

Employee education, learning, and development, according to Bedrnová and Nový (2007), occupy and significant and essential place in the personnel management of each organization. Its objective is to employ technically skilled employees at all levels who take initiative and are flexible with regard to managing the demands of and given position.

Dvořáková et al. (2007) and Koubek (2007) agree that employee development is more focused on the current position than on employee professional potential, future, and career.

Kociánová (2010), Koubek (2007), Vodák and Kucharčíková, (2011) present the opinion that organizations are nowadays exposed to a range of external influences and situations that result in the necessity to adapt the capabilities of workers to changing conditions in their positions. Of course, Robbins et al. (2003) demonstrate that many employers nonetheless oppose educational and developmental activities as they assume that either academic institutions or the employees themselves should be responsible for technical/professional preparation. From the results of the study by Vnoučková (2014) it can be determined that within the Czech Republic in general, organizations support employee education and development, but the initiative should not be missed on the part of the employee. This issue is further specified by Constantine (2012), who states that while long-term development remains the responsibility of the given employee, the organization is fully responsible for professional development. According to this author employees may be accepted with a certain set of skills, knowledge, and capabilities, but at the moment the role and responsibilities of the given position change, the company has a social responsibility to invest into its human capital. As part of the analysis carried out by the company PPM factum (2012) among employees of regional governments it was determined, for example, that a mere 18% of respondents Strongly Agree with the statement that they have enough opportunities for constant expansion of their knowledge and skills. 60% of the respondents Somewhat Agree and 22% Do Not Agree.

Tureckiová (2004, p. 89) considers company education as the main tool applied in employee development. They define this as improvement, expansion, deepening and or change to the structure and content of the professional competency of the employee, which contributes to the aforementioned increased productivity of individuals and the company as a whole.

According to Armstrong (2007, p. 509) employee development consists of allowing employees not only to develop and learn, but also to engage in diverse educational events, and a critical attribute is also planning, execution, and assessment of educational and development programs.

As far as the employee development programs mentioned are concerned, the majority include various training techniques, plans, and a learning environment which helps employees to improve their skills and later apply them in their work (Gerbman, 2000). Of course, according to Koubek (2007) nowadays traditional methods of employee education are no longer sufficient. Much more often they consist of *"developmental activities focused on forming a broader base of knowledge and skills than that currently required by the position and not least the formation of the employee personality, the formation of their value orientation, the adaptation of their culture to the culture of the organization"* (Koubek, 2007, p. 252). Thanks to these development activities the flexibility of the employee is formed, as well as their preparedness for change.

Lee and Bruvold (2003) determined that company investments in employee education and development contributes to positive employee perceptions of the organization. It can be deduced from studies by Schmidt (2007) that employees in general appreciate options for development, education, or training and consider them an essential component of their work.

Moreover, Champathes (2006), Antonacopoulou (2000), Nel et al. (2004), Lee and Bruvold (2003) see a very close link between development of employees and their productivity. With development the professional satisfaction of employees increases (Edgar and Geare, 2005; Georgellis and Lange, 2007), they are more devoted to their work and as a result their performance improves as well. This is confirmed by Dvořáková et al. (2007), who evaluate investments in people (via their development0 in the form of systemic improvement not merely of individual performance but also of team and company performance. An employee may therefore at the present be considered as a wealth of the company, an asset or a human capital, whereas investments in them consist of the very opportunities for education and development (Armstrong, 2005, p. 27).

Indeed, increased satisfaction, motivation, engagement, and loyalty may bring an organization a number of advantages. Tureckiová (2004), Dvořáková et al. (2007) cite the following, for example: the overall improvement of the company image, better applicability of employees on the job market, or improvement of employee quality of life. Nel et al. (2004) add, for example, positive changes in employee behaviour, ability to advance, minimum need of supervision, or reduction in turnover. Nor can be overlooked, of course, certain pitfall associated with employee development. Among them the authors particularly rank costs associated with employment and increased risk of employee defection to the competition due to their increased value on the job market.

Lipman (2013) sees a basic problem associated with employee development overall in ignoring this valuable activity or in the fact that many companies consider it merely a bureaucratic necessity. Companies can subsequently pay the highest tax – key/talented employees.

As part of issues of employee development it is also important o specify the term self-development. Folwarczná (2010) defines it as striving for continuous self-refinement, which emphasises the importance of lifelong learning. The primary responsibility for the process of learning in this case is transferred directly to the individual doing the learning. Deibl (2005) adds that self-development serves primarily for enriching the person themselves, consisting of a tendency to do everything the individual perceives as within his/her capabilities.

According to Folwarczná (2010, p. 77) the existence of efforts for self-development of course depend on several basic assumptions. Among them are a company culture that supports self-development, the interest and support not only of employees but of the leadership themselves, and the willingness of managing employees to change to change the manner of their work as part of their responsibilities. An option to enable developing individuals to continue working on non-standard projects even after the completion of the self-development program plays a role as well.

As noted by Vodák and Kucharčíková (2011), of course, self-development should in no way operate without the critical attribute of motivation. A willingness to improve is a very significant element of any educational process as it is motivation which to an undeniable extent influences the effectiveness of learning and development. Motivation therefore generally helps organizations create an encouraging work environment and situations in which employees can apply their skills and capabilities (Armstrong, 2007).

Motivation may also be divided according to Armstrong (2009) and Kociánová (2010) into internal and external motivation. The authors include as external motivation both compensation (increased salary, praise, acknowledgement and recognition, promotion), and punishment (disciplinary proceedings, docking pay, criticism). On the contrary, inner motivation is composed for example of the aforementioned opportunity to apply and develop ones skills and capabilities, but also the prospect of interesting and stimulating work, freedom to act or the opportunity to functional progress and personal success. Osborne (2002) afterward designates meaning, importance, and the utility of work performed as the primary determinants of professional satisfaction.

Furthermore Stýblo (2013) identifies certain cross-sectional trends that pertain to successful people motivation. Among them he includes more effective work with employee benefits, support of independence, willingness to assume rights and responsibilities for work performed, better and more effective use of employee potential, and creation of space for their engagement.

Malátek (2011) presents the opinion, given no company in interested in having their products and services out-dated, that the systematic development of employees is therefore required. On the other hand, employees welcome development especially because they can use it to satisfy their social and psychological needs (e.g. self-actualization, growth on the social ladder, etc.). For these reasons a number of organizations therefore offer their employees so-called supplemental development, which is not dependent on the requirements of the given work position. Veber (2005) adds that surveys indicate that apart from increasing their professional standard, the option of development and increased qualifications acts as a very strong element associated with motivation for work, employee stability, and the creation of good relationship to work in general.

On the basis of the information stated it is therefore possible in conclusion to agree with Armstrong (2007) that the general goal of employee development is to ensure that the organization has employees of the quality it needs to achieve its goals. This is possible to achieve only once employees acquire the knowledge and skills necessary for the effective performance of their work and its continuous improvement, which will ultimately maximise their potential for growth.

Materials and Methods

The data were mainly extracted from secondary sources and our analysis and discussion is linked to outcome synthesis and the evaluation of international research results and the results come from primary survey.

The survey was carried out using employees. The employee data set comprised 125 employees. The employees were employed full time. Most employees, 82%, have other than managerial positions. They are rank-and-file employees and 70% have no university education.

The employee respondents were structured as follows:

- employee age category: 11% – 20 to 24 years, 32% – 25 to 30 years, 35% – 31 to 40 years, 20% – 41 to 50 years and 2% over 51 years;
- employee professional experience: 10% – less than 1 year, 36% – more than 1 year and up to 5 years, 26% – more than 5 years but less than 10 years and 28% more than 10 years;
- employees work in the following industries: 1% primary sector, 18% secondary, 81% tertiary;
- employees work for organizations of size: 26% small, 29% medium, 45% large organizations;
- employees work for organizations owned by: 74% Czech organizations, 7% Czech organizations with a foreign owner, 19% multinational organizations.

The data collection instrument included questions to measure the activities of learning and development support in organisation. The questions were designed based on theories (see theoretical background) and similar researches driven by Colvin (2010), Gannon and Maher (2012), Michela (2007) and Vronský (2012).

Respondents' reactions to target statements and their attitudes to the given matter were restricted by offering a set of several statements. The extremes of the seven-point scale represented bipolar concepts of the evaluation dimension. All the questions were measured in a Likert type scale with verbal anchors in 1 (strongly agree) and 7 (strongly disagree) or, provided it was not possible to favour either of the sides, selected a median, neutral value (the median value was characterized by number 4). The scale permitted not only the specification of respondents' attitudes, but also their intensity.

The data were evaluated using the tools of descriptive statistics and the methods of comparison, induction, deduction, and synthesis. Descriptive statistics used to test the results included absolute and relative frequency, correlation analysis. Further analyses were based on multidimensional statistical methods – factor analysis (Varimax rotation; the Kaiser-Guttman rule was applied to select a group of significant factors. Following the recommendations of Anderson (2009), only determinants with an absolute value exceeding 0.3 were selected as significant for factor development; positive and negative dependency was further analysed in relation to its final benefits).

To evaluate the data IBM SPSS Statistic Data Editor, version 22 and MS Excel was used.

Results and Discussion

Results have indicated that a total of 43.2% of employees tend toward the opinion that the organization in which they work is devoted to the development of talented employees. It can therefore be expected in the current competitive environment and increasing globalization that more and more organizations will focus on the development of talented employees. Given the results of analyses, practice, and the demographic evolution of the populace it can be stated that the number of talented individuals in the population is relatively limited. For this reason the area of development of current employees is an increasing interest of organizations in that it allows them to increase the competitiveness through effective use of the potential of individual employees.

And yet every employee has a different view of the opportunity to develop his knowledge, capabilities, and skills. One group of employees prefers expanding rights and responsibilities, another enhancement of work or participation in training courses or involvement in talent programs, for example. Every organization should offer each talented employee the option to develop their strong points, improve their individual overall performance within their individual competencies, strengthen their motivation, and enable their career development.

For this reason, respondents in this study from the ranks of employees in organizations were asked whether they have the opportunity to develop their competencies in the organizations where they work and how they perceive their own development. How the individual employees perceive this opportunity for development was determined using the Likert scale 1-7 (1- strongly agree and 7-strongly disagree) for 12 selected assumptions (A through L, see table 1), which were based on theoretical perspectives of work.

Statement	Mark
I have enough possibilities to ongoing development	A
I use my skills and abilities on regular basis on my job position	B
My job is inspiring and interesting	C
My job gives me feeling of personal success	D
My job is beneficial and valuable	E
I take responsibility without any problem for my job tasks	F
Organisation support my development	G
Possible learning and development motivates me	H
Organisation offer possibility of awards for outstanding work outcomes	I
Development affects my work performance	J
I participate on my development regularly	K
Development and education is part of my job	L

Tab. 1: Statement of respondents

The results in table 2 present the relative frequency of answers from the individual employees in the individual tested assumption. On the basis of the results assessment it can be said that the majority of respondents (33.6%) inclined toward answering that they Somewhat Agree that they have enough opportunities for constant expansion of their skills. A total of 73.6% of respondents ranked these opportunities positively. Only 4% of those addressed stated that they have no opportunities for development.

More than 34% of the respondents stated that they entirely agree that they are able to make use of their abilities and skills in their work, this trend is also positive as it can be stated that 86.4% of the respondents tended toward a positive response, with merely 10.4% of those addressed inclining to answer that they do not have any opportunity to use their skills and capabilities in their work to any great extent. A mere 3.2% of respondents responded neutrally.

It can also be said that most of the respondents (35.2%) entirely agree that for them work is stimulating and interesting, that they perform useful work (35.2%) and that they understand development and continuous learning entirely as part of their work (30.4%). The most varying answers were to the question of whether their organization offers the option for recognizing excellent results in work or competition. A total of 49.6% respondents tended toward positive answers, 12.8% to neutral answers and 37.6% to negative answers. The results conform to the fact that a mere 43.2% of respondents inclined to agree that their organization tries to support talented employees. Detailed results for the individual tested assumptions are indicated in the table below.

Statement	1	2	3	4	5	6	7	Total
A	19.2	33.6	20.8	4.8	8.8	8.8	4	100
B	34.4	36	16	3.2	7.2	2.4	0.8	100
C	35.2	32.8	17.6	5.6	4.8	4	0	100
D	28	29.6	19.2	11.2	4.8	4	3.2	100
E	35.2	32	14.4	8	4.8	4	1.6	100
F	37.6	38.4	16.8	5.6	1.6	0	0	100
G	20.8	20	22.4	9.6	11.2	9.6	6.4	100
H	31.2	38.4	15.2	8	4	3.2	0	100
I	11.2	20	18.4	12.8	11.2	14.4	12	100
J	23.2	41.6	11.2	14.4	4	3.2	2.4	100
K	29.6	33.6	17.6	9.6	4.8	3.2	1.6	100
L	30.4	18.4	22.4	11.2	8.8	3.2	5.6	100

Tab. 2a: Statements of respondents in relative frequencies

Statement	1	2	3	4	5	6	7	Total
A	24	42	26	6	11	11	5	125
B	43	45	20	4	9	3	1	125
C	44	41	22	7	6	5	0	125
D	35	37	24	14	6	5	4	125
E	44	40	18	10	6	5	2	125
F	47	48	21	7	2	0	0	125
G	26	25	28	12	14	12	8	125
H	39	48	19	10	5	4	0	125
I	14	25	23	16	14	18	15	125
J	29	52	14	18	5	4	3	125
K	37	42	22	12	6	4	2	125
L	38	23	28	14	11	4	7	125

Tab. 2b: Statements of respondents in absolute frequencies

On the basis of an assessment of the data collected it can be stated that most of the respondents inclined to think that their work more or less gives a feeling of personal success, consider assuming accountability for resolving work tasks as an opportunity to gain experience, and are themselves motivated to work on themselves and to deepen their knowledge and obtain new knowledge.

The results of the study can be summarized to state that a development program should be prepared and executed by the organization and monitored by managers which can take into account the individual needs of the individual employees.

Furthermore, factor analysis was made in consequence to correlation matrix which have shown relations between all variables. Regarding overall medium till strong dependences between variables, constructed for the survey for the reason of their clear use in the construct, it was expected to find statistically significant factors. Correlation coefficients of variables used for factor analysis were optimally strong to give significant results by Varimax rotation method. As shown in Table 3 and 4, factor analysis revealed 3 statistically significant factors. To separate final amount of output factors a Kaiser-Guttman rule was employed.

Factor	Total variance	Total % of Variance	Cumulative % of Variance
1	5.833	48.610	48.610
2	1.363	11.360	59.970
3	1.145	9.546	69.516

Tab. 3: Variance explained by factors

Such factors were used for further analysis, whose variance was higher than 1.0. This value wa chosen rationally because explanatory factor must have at least equal value as original standardised determinant. Such variables (statements of respondents) were chosen as significant to create resulted factor, whose value was 0.3 and higher (Anderson, 2009). Factors together explain 69.52% of behaviour of total construct.

Variable	Factor 1	Factor 2	Factor 3
A	0.400	**0.742**	-0.098
B	**0.834**	0.196	0.153
C	**0.783**	0.364	0.180
D	**0.781**	0.396	0.144
E	**0.739**	0.401	0.249
F	**0.552**	-0.246	**0.523**
G	0.378	**0.684**	0.235
H	0.264	0.087	**0.684**
I	0.088	**0.618**	0.361
J	0.225	0.253	**0.798**
K	-0.042	**0.456**	**0.714**
L	0.336	**0.686**	0.324
% of variance	**48.160**	**11.360**	**9.546**
Name of the factor	Knowledge employee	Talented employee	Developing employee

Tab. 4: Resultant factors by method Varimax

The first factor (Factor 1) describes an employee who is satisfied with its job, working in its area of interest, using gain knowledge, skills and abilities. Such employee is willing to be responsible for its work tasks and search for strategic importance of its job position. He/she sees his/her position as interesting and developing, giving the social status and personal success. Additionally, such employee thinks his/her job supports home organisation and also society. Thus we may summarize that the factor describes a knowledge employee because of its current and still developing knowledge used at work process, interest in job position and organisation and willingness to work for it in the best manner. The name of the first factor therefore is Knowledge employee.

The first factor is also found on the first place by factor analysis as the most significant, which is proved by the highest variance of this factor (5.833). It is the highest variance above all factors found by factor analysis. Together almost half of surveyed employees (48.16%) behave in this manner and see their employer as cooperative and good place to be and work.

Factor number 2 revealed different type of employee behaviour. The second type of employees stated they have enough possibilities to be developed and to grow constantly in their organisation; their home organisation supports employee development, education and learning. Additionally, home organisation offers special rewards and awards or appreciation of superior outputs at work; employees in that organisation may compete in different competitions focused on work, projects and other concepts. Employees grouped by Factor 2 are also constantly developed and take part on development program periodically or on regular base. Employees also stated that development, learning and education is part of their job.

Such description evokes talent employees who are part of talent pool or talent program. Described organisational environment is quite superior, supporting talented employees and profiting from their constant development. Total 11.36% of employees work in described environment and may be considered as talents.

The third factor (Factor 3) revealed constantly developing employee. He/she is characterized by motivation to learn and being educated and developed, he/she is constantly part of development program. Revealed type of employee also takes responsibility and is aware of self-management which is familiar for him/her. Moreover, development of an employee have straight impact on employees work.

Factor 3 therefore describes constantly developing employee in the way his/her job position is being developed. Thus the name of the factor Developing employee. Almost 10% of respondents work in this kind of organisational culture.

Based on presented results of analyses we found about 70% of surveyed employees to be really developing by their organisations or at least are motivated to be developed: in the manner of knowledge employee, talent employee or developing employee. Such results seem quite positive, but still there are questions. Basically, 30% of employees do not use knowledge, talent or development techniques or are not supported in their development by their home organisation, they have no possibility to grow and there are no succession or career plans for them. Based on the results of descriptive statistics, 27 % of employees do not feel any possibility to grow and that may lead to disaffection, loss of production or even to employee turnover. Employees, who miss adequate level of development are usually key and knowledge employees; it is necessary to support their career plans and development to retain them in organisation.

Anyway, 70% of employees are being educated, going through constant learning, development or talent program seem to be quite a good result. On the other hand, based on other similar researches, just about 20% of employees (measured in the population) are being developed (Maršíková, Šlaichová, 2014; Linhartová, 2012) or can be named as knowledge workers or talents (Linhartová, 2012). This may occur because only such employees, who are interested in development programme, took part in the survey; the others refused to answer.

As we analysed different size of organisations (small, medium, large), there was a potential of different results according to size of a company, age of respondents etc. We found, similarly as results of other similar surveys or researches (i.e. Benito-Hernandez et al., 2015; Denicolai et al., 2015; Weitlaner, Kohlbacher, 2015; Linhartová, Urbancová, 2012; Urbancová, Linhartová, 2012; Linhartová, Urbancová, 2011), that there is not statistically significant difference. On the other hand, we found that mainly small, micro, and then large multinational organisations use such methods and approaches as talent management, knowledge management and for example mobility management. The results of those surveys revealed that small and micro companies are managed according to modern trends of management to keep competitiveness. Also, large international organisations have all those processes internally described and followed according to their foreign management who is used to those methods. Usually, the biggest gap can be found in medium organisations, which still have not incorporated modern practices to use them in praxis and daily processes. Anyway, the sample consists of 125 responses, thus it is possible to provide this analysis as the distribution of responses is appropriate and in accordance with results of other similar surveys.

Conclusion

Presented paper analysed possibilities of employee development in organisations. Research outcomes identified types of employee development programmes and attitudes of organisational learning. Results describe the main types of employee behaviour during development. Based on presented results, 69.52% of respondents have an opportunity of being developed or are internally motivated for development. We may also describe possibilities of employee development in Czech organisations as following three approaches (based on results of factor analysis): Knowledge employee management, Talent employee management and Developing employee management. Employees are both self-motivated and self-managed or supported by their home organisation.

Based on presented outputs, we may evaluate possibilities of employee education and development. Firstly, it is employee him/herself, who sees the potential and willing to grow (Factor 1 – 48%). It is a pleasure to work with such employee in organisation. He/she wants to be developed and search for opportunities him/herself inside or outside the organisation and uses his/her knowledge to upgrade his/her work outputs. Secondly, he/she is a part of talent program already running in an organisation (Factor 2 – 11%). Such employee works in line with organisational program and understands its reason. Development of employees in such organisation is smooth and both sides know the reason and necessary steps. Finally, third type of employees (Factor 3 – 9.5%) is searching for development. They are motivated for self-development and try to be constantly part of development program. They are responsible and thus it is easy to educate and develop this type of employee. Organisations which have any one of described type of employee may have competitive advantage in the future labour market.

Besides this study there are several promising avenues for further research. It would be useful to know the impact on employee mobility and total outputs of an organisation. Link between employee behaviour in the revealed 3 types and organisational outputs would be interesting study for research in the future.

A theoretical benefit of this article is the summary of characteristics of talented employees in the organizations studied. A practical benefit of this article is the determination of what options for education and development are preferred by these employees. Organizations can modify their development programs according to the 3 types of employees defined and their attitudes toward development. Given the number of respondents (n=125) the study results can be generalized only to the given sample set. And yet this study in the area of talent management will be repeated on an ongoing basis with the prerequisite of addressing a larger, representative sample of employees.

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THE SUBJECT OF STATISTICS IN NATURAL SCIENCE CURRICULA: A CASE STUDY

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Highlights

- *Undertake curriculum and course design in a multidisciplinary team*
- *Spidergrams can provide a useful tool in curriculum and course design*
- *Course design should minimize extraneous cognitive load and optimize intrinsic cognitive load*

Abstract

Statistics is considered to be an indispensable part of a wide range of curricula across the globe, natural science curricula included. Teachers and curriculum developers are typically confronted with four questions with regard to the role and position of statistics in a curriculum: (1) how to integrate statistics in the curriculum; (2) which topics to cover and in what detail; (3) how much time to allocate to statistics in a curriculum; and (4) how to organize a course and which study materials to select. This paper addresses these four questions through a case study: four curricula at Charles University, Prague, Czech Republic, are compared in terms of how they address these four questions. Placing this comparison in a framework of cognitive load theory and two decades of research inspired by this theory, this paper concludes with a number of guidelines for addressing the aforementioned four questions when designing a curriculum.

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Introduction

An enormous growth of data and information load has contributed to the fact that statistics is considered an indispensable part of a wide range of curricula across the globe, natural science curricula included. Students are taught to make sense of the multitude of quantitative data and learn to engage in quantitative thinking and reasoning.

Problem of Research

Teachers and curriculum developers typically have to answer four interrelated questions with regard to the role and position of statistics in a curriculum. Firstly, in natural science, statistics generally serves as a means for doing research; it is not a goal in itself. In this context, statistics is one of a series of subjects to be integrated in a curriculum. To provide students with opportunities to practice with statistical content and to illustrate that statistics can provide them with tools to address questions and challenges in their field, the subject of statistics needs to be properly integrated in the curriculum at hand (Leppink, 2012). The first question to be addressed by curriculum developers and teachers is therefore how to integrate statistics in their curriculum.

Secondly, each curriculum has different needs and attracts different populations of students. Prior knowledge of statistics may vary considerably among students who enter a statistics course in a given curriculum. It is of crucial importance to consider this variation in prior knowledge, as this has crucial implications for instructional design of a course. Various studies in statistics education have demonstrated a so-called expertise reversal effect in statistics education (Leppink, Broers, Imbos et al, 2012a, 2012b, 2014). Succinctly put, instructional methods that are effective for students who have little prior knowledge tend to lose their effectiveness and may even affect learning negatively among their more knowledgeable peers (Kalyuga, Ayres, Chandler et al, 2003; Kalyuga, Chandler, Tuovinen et al, 2001). This robust finding from educational research and the specific needs of a given curriculum give rise to second question, namely which topics to cover and in what detail.

Thirdly, sufficient time should be allocated to the subject of statistics to avoid that most students develop an only superficial understanding of the content covered. Frequently, part of the time allocated to the subject is used to make students familiar with statistical software. Moreover, a proper understanding of core concepts appears to require at least a basic understanding of formulae and mathematical relations. Many students entering natural science or other (e.g., social and health science) curricula in which statistics is a tool but not a goal in itself lack such an understanding, meaning that some time should be reserved for increasing that understanding. However, there is a tradeoff. On the one hand, the aforementioned factors require that a sufficient amount of time be reserved for the subject. On the other hand, statistics is but one in a chain of many subjects forming a curriculum. This tradeoff typically requires curriculum developers and teachers to come to a practical compromise on a third question, namely that of the amount of time to allocate to the subject given the function and position of the subject in the curriculum at hand.

Fourthly, the three questions addressed until here – how to integrate statistics in the curriculum, which topics to cover and in what detail, and how much time to allocate to the subject in the curriculum – naturally lead to a fourth question: how to organize a statistics course and which study materials to select. The aforementioned expertise reversal effect is of crucial importance here and is one of the merits of well-designed experimental research inspired by cognitive load theory (Sweller, 2010; Sweller, Ayres and Kalyuga, 2011). In cognitive load theory, learning is defined as the process in which new information elements are related to knowledge available in long-term memory, resulting in more elaborated cognitive schemata. However, whether learning takes place depends on the intrinsic complexity of the new information as well as on the way in which that information is presented. The more working memory capacity is needed for dealing with the way in which information is presented (i.e., extraneous cognitive load), the less working memory capacity remains available for dealing with the intrinsic complexity of the information (i.e., intrinsic cognitive load). For instance, if a distributional concept that should be presented graphically is presented textually, this is likely to impose a relatively high extraneous cognitive load on students, meaning they have fewer resources available to actually learn what the distributional concept is about. Likewise, instructional methods that require students with limited prior knowledge to engage in problem-solving search activity impose an extraneous cognitive load that may disable them to deal with the actual content (Kalyuga et al, 2001, 2003; Leppink et al, 2012a, 2012b). Simultaneously, however, instructional guidance that can greatly reduce extraneous cognitive load among novices (through a reduced appeal on problem-solving search activity) may require more knowledgeable students to process information they no longer need and as such increase extraneous cognitive load.

Research Focus

No matter where or in what curriculum statistics is taught, the aforementioned four questions arise naturally. A cross-country comparison or a comparison of universities in a country could yield interesting insights with regard to how different universities address these particular questions. However, an advantage of a case study is that it enables one to zoom in on key choices and discuss these key choices from an educational theory and research perspective. Whether it is about curriculum design at the University of South Bohemia, the University of Veterinary and Pharmaceutical Sciences in Brno, another university in Europe or a university elsewhere, the same four questions have to be addressed. Therefore, this paper does not provide a cross-university comparative review, but addresses these questions through a case study to discuss key choices more in depth.

Four curricula at Charles University, Prague, Czech Republic, for prospective teachers of biological topics are compared in terms of how they address these four questions. Placing this comparison in a framework of cognitive load theory and two decades of research inspired by this theory, this paper concludes with a number of guidelines for addressing the four questions every curriculum developer and teacher has to address when designing a curriculum or course within a curriculum. These guidelines can also provide a useful framework for cross-university comparisons of how the four key questions are addressed.

Methodology of Research

General Background of Research

Through content analysis, the following four curricula are compared: (1) the Bachelor of Biology, Geology, and Environmental Science (FEBGES), (2) the Master of General Education Subjects for Elementary and Secondary Schools (Biology), (3) the Bachelor of Biology, and (4) the Master of Biology Education for Secondary Schools. The first two curricula are organized by the Faculty of Education (henceforth: FE Bachelor and FE Master, respectively), while the latter two curricula are part of the Faculty of Natural Sciences (henceforth: FNS Bachelor and FNS Master). The two Master's curricula are potential follow-ups of the two Bachelor's curricula. All four curricula focus on preparing students for a practice of teaching biological topics.

The FE Bachelor involves neither compulsory nor optional courses with statistical topics, whereas FE Master's students must complete a biostatistics course. FNS Bachelor's students are given the option to take an elementary biostatistics course, and the FNS Master includes a mandatory course on research methods in natural science education. A concise overview of the four curricula in terms of statistics coursework is presented in Table 1.

Curriculum	Course and link to syllabus
FE Bachelor	None
FE Master	Biostatistics (ON2302052, mandatory)
FNS Bachelor	Elementary biostatistics (MS710P09, optional)
FNS Master	Research methods in natural science education (MB180C41, mandatory)

Table 1. Overview of the four curricula compared in this paper

Content Analysis

The three statistics courses were analyzed with regard to the aforementioned four key questions: (1) how to integrate statistics in the curriculum, (2) which topics to cover and in what detail, (3) how much time to allocate to the subject in the curriculum, and (4) how to organize a statistics course and which study materials to select.

With regard to the second question, coverage of ten statistical topics that have countless applications in biological research was evaluated: (a) introduction to statistical methods, (b) probability theory, (c) random event and its probability, (d) sampling and descriptive statistics, (e) hypothesis testing, (f) two-sample comparison, (g) non-parametrical methods, (h) categorical data analysis, (i) time series, and (j) measuring statistical dependence (correlation and regression). The courses were compared in terms of level of implementation or detail. Spidergrams were used since these enable one to contrast various ordinal variables. Following standard content of complex statistical textbooks (Pagano and Gauvreau 2000), the following 0-5 assessment was made for each of the ten topics (a-j): the topic does not occur in the syllabus (0); the topic is mentioned in the syllabus but remains unspecified (1); the topic is included in the syllabus along with a brief outline of its essence (2); the topic is described in the syllabus with the omission of some subtopics (3); the syllabus presents an elaborate description of the topic but without mathematical details (4); the syllabus comprises a detailed presentation of the topic including the mathematics underlying the topic (5).

The use of spidergrams is in line with Vondra and Vltavská (2014), who used spidergrams to analyze study plans and to compare the structure of subjects and their relevance according to the opinions of students and academic staff.

Results of Research

FE Master's course in biostatistics

In two seminars of 90 minutes each, the mandatory FE Master's course in biostatistics introduces students to elementary statistical terminology, the potential of analysis and statistical data presentation, elements of inductive thinking along with the most frequently used statistical methods, the conditions of their usage as well as their potential and shortcomings. Besides, there is attention for the interpretation of outcomes of biological and pedagogical studies. Figure 1 presents the spidergram for the FE Master's course in biostatistics.

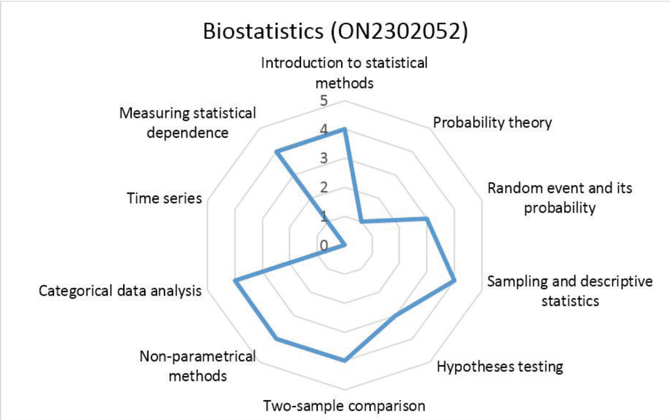

Figure 1: Spidergram for the FE Master's course in biostatistics.

Figure 1 illustrates a clear emphasis of the course on the introduction to statistical methodology, sample and descriptive statistics, two-sample comparison, categorical data analysis, and non-parametrical methods.

The course highlights the significance of biostatistics in biology and teaching and covers graphical and numerical tools for one-dimensional as well as multidimensional data (Hybšová, 2013). Hypothesis testing in biostatistics is covered through a presentation of the following tests: *t*-test, *F*-test, Mann-Whitney test, Wilcoxon test, sign test. Further, correlation (Pearson's and Spearman's coefficient), contingency table analysis, and simple and multiple regression are covered.

The course is completely free of mathematical proofs and mathematical essence of the methods presented. The course aims at acquainting students with the potential of statistics. If students are interested, they are given a sufficient ground for deeper study. Recommended study materials include textbooks written by Chráska (2010) and Gavora (2010) who attempted to adapt their explanation to a reader with secondary school knowledge of mathematics.

FNS Bachelor's course in biostatistics

The optional FNS Bachelor's course in biostatistics includes a wide range of topics: (1) descriptive statistics; (2) relative frequency and probability, independence, and Bayes' theorem; (3) random variables and their distributions and features; (4) sampling theory, parameter estimation, and the hypothesis testing principle; (5) parametric and non-parametric tests for single and paired samples, (6) tests for two independent samples, (7) spread-analysis principle, (8) correlation and regression, (9) contingency tables and (10) measuring statistical dependence (Zvára, 2014). Figure 2 presents the spidergram for the FNS Bachelor's course in biostatistics.

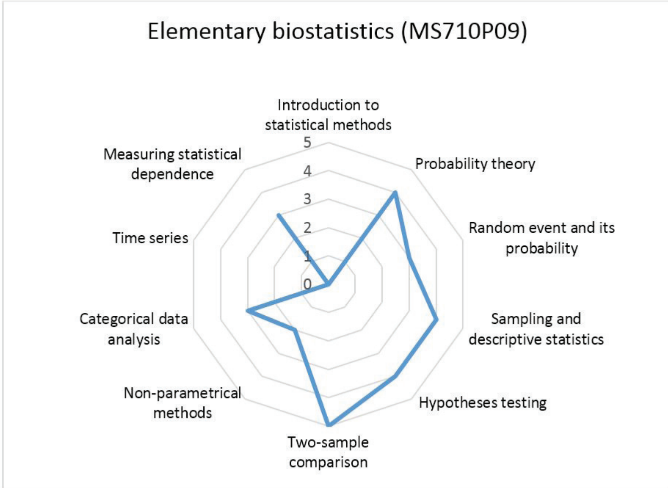

Figure 2: Spidergram for the FNS Bachelor's course in biostatistics.

The most thoroughly covered topic is that of two-sample comparison. Course seminars take place in computer laboratories and use R as statistical software. Students learn to use common statistical procedures, using their own real data. In more complicated cases, students are encouraged to ask for qualified assistance.

The compulsory reading list includes more mathematically-oriented textbooks by Zvára (2001, 2013, 2014) and Havránek (1993) that require advanced, university-level knowledge of mathematics. Although the combination of lectures (two times 90 minutes) and seminars (two times 90 minutes) adds to the strength of this course, the use of R does require some programming skills and can make the course challenging.

FNS Master's course in research methods

The FNS Master's course in research methods consists of only two seminars of 90 minutes each and focuses on quantitative and qualitative methods of pedagogical research in methodology of natural sciences with an emphasis on biology. In fact, students are presented with tools for writing their thesis. Students learn about research planning, generating testable hypotheses, and basic data collection methods. The introduction to types of variables and basics of statistical data analysis and evaluation constitutes an integral part of the course. Figure 3 presents the spidergram for the FNS Master's course in research methods.vv

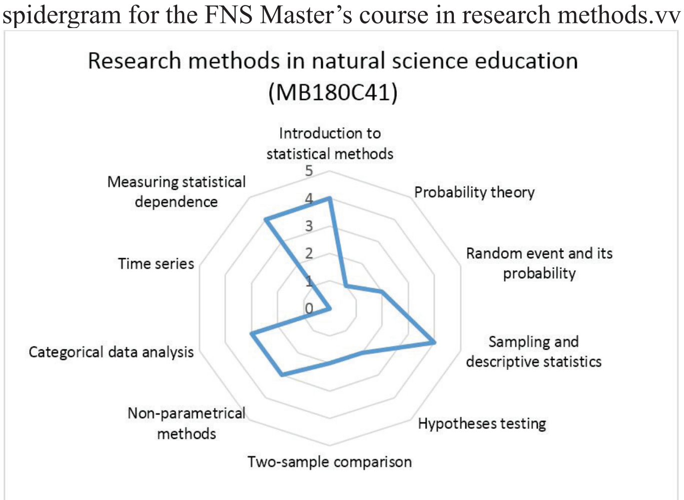

Figure 3: Spidergram for the FNS Master's course in research methods.

Students receive a detailed overview of the introduction to statistical methodology, sample and descriptive statistics, and dependence of quantitative data. Non-parametric methods and categorical data analysis are covered with less detail and the syllabus completely omits other areas, such as time series.

The compulsory course literature comprises Chráska (2010) and Gavora (2010) for the quantitative part and Švaříček and Šeďová (2007) for the qualitative part. These textbooks appear much more suitable for the needs of teachers than the books used in FNS Bachelor's course in biostatistics; the explanations are much more gradual, with no mathematical elaboration, and therefore easier to grasp by students who have a non-mathematical background.

Discussion

Cross-curricular comparison of topic coverage and consequences for students' learning

The FE Bachelor does not include any course that covers statistical content. A potential advantage of this approach is that more time remains available for biological content, communication and teaching skills, and other knowledge and skills that can make a good teacher. However, having had no statistical coursework at all leaves students unprepared for research and research-oriented Master's curricula.

Meanwhile, given that in many Master's curricula – the ones discussed in this paper are exemplar for non-mathematical Master's curricula across the globe in this respect – include at most one course that addresses a selected set of topics in a limited period of time, students graduating from a Bachelor's curriculum that includes no statistical coursework may not have the necessary groundwork for developing a proper understanding of the statistical content covered in the Master's course.

The effectiveness of statistical coursework in Master's programs is generally built on the premise that students have an at least basic understanding of core statistical concepts. In the light of the aforementioned expertise reversal effect, this is problematic, as instructional methods that work for students who have a certain knowledge tend to be less effective for students who lack that knowledge. Thus, including at least one mandatory statistics course in a Bachelor's curriculum appears desirable.

A major strength of the FNS Bachelor's course in biostatistics relative to the other two courses discussed in this paper is that dedicates a substantial amount of time to probability theory. In the light of commonly encountered and persistent misconceptions about conditional probabilities like the p-value in null hypothesis significance testing (Fidler and Cumming, 2010), covering probability in sufficient detail in a statistics course appears a wise choice.

However, two main challenges for students taking the FNS Bachelor's course in biostatistics are the use of a statistical package that requires programming skills and the mathematical presentation of topics that should be presented in a more conceptual manner to students who have a non-mathematical background. From a cognitive load theory perspective, all resources students have to allocate to dealing with programming difficulties are simply not available for dealing with the intrinsic complexity of the actual statistical content. Since programming skills are in essence extraneous to purely statistical content, any mental effort to be invested in learning how to use a program is extraneous to learning; it does not contribute to the actual goal of the course, if that goal is to learn statistical content.

A similar reasoning holds for a mathematical presentation of statistical concepts. What students in non-mathematical curricula typically need, to become researchers or professionals, is a conceptual understanding of statistics (Leppink, 2012). Any mathematical presentation that is not necessary for such a conceptual understanding is – from that perspective – extraneous to learning and as such imposes an extraneous cognitive load on students that limits their ability to develop a conceptual understanding that is needed to do research or to assess the merits of an empirical study in a practical context. This holds even more when introductory concepts of statistical methodology are not even covered, as is the case in the FNS Bachelor's course in biostatistics. In this respect, the other two courses have an advantage.

As holds for the vast majority of natural, social, and health science curricula, none of the courses compared in this paper covers time series analysis. Although time series analysis is of great use in biology (as it is in for instance econometrics), students need to have mastered quite a number of more basic concepts to start their journey through time series analysis. Given that statistics is only one of many topics in a curriculum, and part of the time for a statistics course needs to be spent on software, only a limited number of topics can be covered in a course in such a way that students can digest most of the content.

Therefore, it appears wise to leave time series analysis for curricula that attract PhD candidates who need time series analysis in their research. Of course, the latter recommendation is built on the assumption that the PhD candidates' knowledge of more basic statistical concepts be sufficient to get started with this course; otherwise, candidates should be encouraged to go through more basic coursework first.

Finally, the FE Master's course – more than the other two courses – pays attention to non-parametric methods. Considering the fact that data may violate conditions for the use of parametric methods, including non-parametric methods in the course appears a wise choice, even if this comes at the cost of covering more advanced parametric tools which require the student to have mastered more basic concepts anyway.

Guidelines for curriculum and course design

Students frequently develop an only superficial understanding of statistics because they take a course for which they have not been prepared or a course that presents the content in a way that is of at best limited practical use (Kvasz, 1997; Leppink, 2012). This constitutes two arguments against a predominantly mathematical presentation of statistical content in a non-mathematical curriculum.

Firstly, students enrolled in a non-mathematical curriculum generally do not have the mathematical background that is needed to understand mathematical formulae and relations underlying statistical concepts.

Secondly, much of the mathematics encountered in mathematical statistics literature is not necessary for doing and understanding the outcomes of empirical research; a proper conceptual understanding of statistics may well do in this context.

For instance, if researchers understand the difference between a standard deviation around a sample mean and a standard error (i.e., the standard deviation of a sampling distribution) and that a way to decrease the standard error – which is part of confidence intervals and statistical significance tests – is to use larger samples, they do not need further formulae to understand that non-statistically significant results and excessively wide confidence intervals are much more likely in a sample of $N = 10$ than in a sample of $N = 100$. Reading a research paper that reports a non-statistically significant correlation in a sample of $N = 10$, they realize that a correlation of the same size would be statistically significant in a sample of sufficient size, and that the reported non-statistically significant outcome should not be interpreted as evidence in favor of the null hypothesis of zero correlation. No mathematical equations enter the argument here.

The most fundamental guideline for curriculum and course design is to undertake this enterprise with a multidisciplinary team. Statisticians know better than anyone else what definitions and arguments are correct and what is incorrect. Unfortunately, the subject of statistics is not rarely taught by non-statisticians who have a limited understanding of key statistical concepts themselves. Persistent misconceptions about the p-value (Fidler and Cumming, 2010) constitute just one example of this. Teaching core statistical concepts incorrectly has negative implications on the short run (i.e., flawed understanding of these concepts among students) as well as on the long run (e.g., continued misuse of p-values and other statistical concepts in empirical research across domains). Having a statistician in the team is therefore recommended.

However, in their enthusiasm about their subject, statisticians typically feel the desire to cover either many topics or specific topics in extensive detail but are frequently also not really aware of how to present these topics to students with a non-mathematical background. This is why including an educationalist in the team is a very good choice.

Finally, one needs to include content experts, for instance biologists in the case of a biology curriculum. The simple reason for this is that that content experts can assess better than anyone else what knowledge and skills define a good researcher or professional in the domain.

Therefore, with a multidisciplinary team that includes at least one statistician, at least one educationalist, and at least one content expert, one optimally increases chances to (1) achieve a good integration of statistics in the curriculum, (2) make appropriate decisions with regard to which topics to cover and in what detail, (3) find a good balance between time allocated to statistics and time available for other knowledge and skills, and (4) organize a course and select study materials such that learning is stimulated to an optimal extent.

The spidergrams used to compare existing courses in this paper can also serve as starting point for curriculum and course development. A careful analysis of the domain and of aims of a curriculum can help a team of curriculum developers and teachers to construct a spidergram detailing what topics should be part of a statistics course in that program, in what detail these topics should be covered given the aims of the curriculum, how much time should be reserved for activities in that course, and eventually how specific topics can reoccur in the form of a practical application in one or more later courses. The spidergrams can also be used to facilitate comparisons of curricula and courses in different universities in a country or in different countries.

Course-specific guidelines

One of the key observations this paper started with is the expertise reversal effect and how this robust phenomenon can be explained in a cognitive load theory framework. This paper concludes with a set of guidelines that can facilitate decision-making with regard to how to learning task complexity and the degree of instructional support provided to students. The basic principle underlying these guidelines is that a course should be designed such that extraneous cognitive load is minimized and students are stimulated to optimally allocate their available resources to dealing with the intrinsic cognitive load arising from the intrinsic complexity of information.

One way of reducing extraneous cognitive load is scaffolding, that is: to provide sufficient instructional support to students with limited prior knowledge (e.g., partially or fully worked examples; Leppink et al, 2012a, 2012b) and to gradually fade that guidance for tasks of a given complexity level as students advance.

A second way of reducing extraneous cognitive load is to present content in a single integrated source of information rather than in multiple sources that are distributed in either space or time (Sweller, 2010). The latter requires students to split their attention between sources and hold information from one source in their working memory while attempting to process information from another source. For instance, providing students with instructions for how to use a particular hypothesis test way before instead of right when students need to apply it requires students to hold information about that hypothesis test during a time interval in which students may also need to process other information.

Modality plays an important role in the effectiveness of instruction. Concepts like a cube, for instance, should be presented visually not verbally. Providing verbal descriptions of a cube, students in the end may or may not realize that it is a cube and not some other object the teacher is describing, but it takes an unnecessary effort to digest information that is not needed when presenting the cube visually. Likewise, verbal descriptions of that cube are redundant when presented along with the cube in visual form; students understand without any additional explanation that the object they see is a cube. Similarly, concepts like shape, center, and variation are often more easily understood when presented visually than when presented in textual form.

Keeping extraneous cognitive load to a minimum is a necessary but not sufficient condition for students to optimally allocate their resources to dealing with intrinsic cognitive load. Firstly, the intrinsic cognitive load needs to be at an optimum. A task of a given complexity level can be expected to impose a higher cognitive load on a novice student than on a more knowledgeable student, because the latter already has more elaborate cognitive schemata of the content in long-term memory than the former. The complexity of learning materials must align with students' prior knowledge of the content for learning to take place. Too easy materials may simply bore students (Young and Stanton, 2002), whereas materials of too high complexity are likely to hamper learning (Ayres, 2001). Therefore, it is important to have learning materials match students' prior knowledge from the start, and attempt to gradually increase complexity as the course advances.

Additional to aligning task complexity to students' prior knowledge, teachers really need to be aware of the extent to which assessment can drive learning. Even if instruction throughout a course is aimed at stimulating students to invest effort in dealing with the complexity of learning materials, if students have the impression that the exam at the end of the course assesses knowledge in a fairly superficial manner, students may mainly feel stimulated to engage in superficial learning (Lafleur, Côté and Leppink, 2015). A somewhat more challenging assessment in combination with a well-designed course that is well integrated in the broader curriculum can stimulate students to invest an optimal effort in learning from the course.

Finally, recent studies have provided self-report measures of intrinsic and extraneous cognitive load experienced by students when processing information (Leppink, Paas, Van der Vleuten et al, 2013; Leppink, Paas, Van Gog et al, 2014). Teachers could start to include these measures in their course to monitor intrinsic and extraneous cognitive load experienced by their students across course activities and to further align task complexity and instructions to students' needs.

The guidelines in eight bullet points

These guidelines can facilitate curriculum and course design and drive future research that involves cross-university comparisons of curricula and coursework:

- Undertake curriculum or course design with a multidisciplinary team
- Spidergrams can provide a useful tool in curriculum and course design
- To reduce extraneous cognitive load, keep the mathematics limited to what is needed to facilitate the conceptual understanding students are expected to develop
- Instructional support should decrease while complexity of learning tasks should increase as students advance in a particular topic
- When introducing a new topic, avoid situations in which students have to split their attention between different sources of information when a single source can be sufficient
- When introducing concepts that are best understood if presented visually, textual descriptions may complement but not replace visual presentations
- Instruction and assessment are two sides of the same coin; learning can be stimulated when the two are appropriately aligned and the course is well integrated in the broader curriculum
- Consider keeping track of intrinsic and extraneous cognitive load experienced by students throughout a course to further optimize course design.

Conclusion

Through a case study, this paper has presented guidelines for curriculum and course design to stimulate students' learning through (1) a good integration of statistics in the curriculum, (2) appropriate decisions with regard to which topics to cover and in what detail, (3) a good balance between time allocated to statistics and time available for other knowledge and skills, and (4) a proper course organization and appropriate selection of learning materials. These guidelines are aimed at minimizing effort needed for processes that do not actually contribute to learning and optimizing the effort invested in dealing with an optimum of intrinsic complexity of content. Task complexity and instructional support must be aligned to students' knowledge and needs throughout the course, and the way in which knowledge is assessed at the end of a course must be such that it stimulates learning. The guidelines provided in this paper can facilitate curriculum and course design and drive future research that involves cross-university comparisons of curricula and coursework.

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IMPACT OF HEURISTIC STRATEGIES ON PUPILS' ATTITUDES TO PROBLEM SOLVING

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Highlights

- *The strategy Introduction of an auxiliary element can be mastered in a shorter period of time*
- *The strategy Omitting a condition requires longer teacher´s work with pupils*
- *A short period of using heuristic strategies changes pupils´ attitudes to problem solving*

Abstract

The paper is a sequel to the article (Novotná et al., 2014), where the authors present the results of a 4-month experiment whose main aim was to change pupils' culture of problem solving by using heuristic strategies suitable for problem solving in mathematics education. (Novotná et al., 2014) focused on strategies Analogy, Guess – check – revise, Systematic experimentation, Problem reformulation, Solution drawing, Working backwards and Use of graphs of functions. This paper focuses on two other heuristic strategies convenient for improvement of pupils' culture of problem solving: Introduction of an auxiliary element and Omitting a condition. In the first part, the strategies Guess – Check – Revise, Working backwards, Introduction of an auxiliary element and Omitting a condition are characterized in detail and illustrated by examples of their use in order to capture their characteristics. In the second part we focus on the newly introduced strategies and analyse work with them in lessons using the tools from (Novotná et al., 2014). The analysis of results of the experiment indicates that, unlike in the case of the strategy Introduction of an auxiliary element, successful use of the strategy Omitting a condition requires longer teacher's work with the pupils. The following analysis works with the strategy Systematic experimentation, which seemed to be the easiest to master in (Novotná et al., 2014); we focus on the dangers it bears when it is used by pupils. The conclusion from (Novotná et al., 2014), which showed that if pupils are introduced to an environment that supports their creativity, their attitude towards problem solving changes in a positive way already after the period of four months, is confirmed.

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Introduction

It is a fact generally agreed on by teachers, mathematics educators and researchers in the field of mathematics education that problem solving is the cornerstone of mathematics taught at all school levels. The posed problems should be more than tasks in which an individual or a group are meant to demonstrate to their teacher how they can apply mastered algorithms. Problems should develop pupils' intellectual activity, simulate work of a mathematician who is facing a problem to be solved, encourage solvers' creativity in the solving process (Brousseau, Novotná, 2008). If problems are to meet these criteria, it is not enough to look for good assignments (although we cannot do without them). It is essential to create suitable environments that influence pupils' relationship to problem solving. We refer to this environment as stimulating learning environment in contrast to Wittmann's (1995) concept substantial learning environment which refers to the context from which mathematics problems arise naturally.

Changes of pupils' attitude to problem solving are one of the phenomena studies in the frame of the GAČR research project Development of culture of problem solving in mathematics in Czech schools. The project explores the possible ways of changing pupils' attitudes to problem solving, of making pupils aware that mathematics problems are the means needed for their own personal development. One of the main questions the research team is trying to answer is the question to which extent this attitude positively influences development of pupils' understanding of mathematics, their approach to creative search for solutions to problems, and their behaviour once they encounter a modified or brand new problem.

Theoretical background

In (Novotná et al, 2013; Břehovský et al, 2013; Novotná et al, 2014), the focus is especially on introduction of heuristic strategies suitable for use in primary and secondary schools when solving problems differently than with school algorithms. The presence of non-routine algorithms in mathematics classrooms in China, Singapore and USA is researched in (Fan & Zhu, 2007). (Elia, van den Heuvel-Panhuizen & Kolovou, 2009) describe an experiment exploring improvement of the ability to solve problems after teaching heuristic strategies by primary school high achievers.

However, most pupils cannot be expected to start using these heuristic strategies unless they are given help, albeit from the teacher or somebody else from outside the school. There are many ways to create of learning environment to make it more stimulating. One of them is the inclusion of problems whose solution is much easier or more convenient if pupils use some (or one) heuristic strategies instead of algorithmic solution typically used in school mathematics.

Creation of a stimulating learning environment in mathematics is not and cannot be a single event. The question is how long a teacher must exert their influence on pupils until it brings positive changes in their attitude to solving of mathematics problems, improves their understanding of mathematics and until their ability to use mathematics in different situations is developed. The paper presents one of the possible approaches to this issue. It reports on a four month teaching experiment described already in (Novotná et al., 2014), in which pupils were repeatedly introduced to the advantages of use of heuristic strategies Analogy, Guess – check – revise, Systematic experimentation, Problem reformulation, Solution drawing, Working backwards and Use of graphs of functions in solving mathematics problems and in which changes in their attitudes to problem solving were detected. It was proved that if pupils are introduced to an environment that supports their creativity, their attitude towards problem solving changes in a positive way already after the period of four months. The most successful of all the studied heuristic strategies used by the pupils were the strategies Guess – check – revise and Systematic experimentation.

The focus of this article is on two other heuristic strategies that can be used on secondary levels: Introduction of an auxiliary element and Omitting a condition. Their use and effect on improvement of pupils' culture of problem solving are subjected to the same analyses as strategies in (Novotná et al., 2014). Attention is also paid to the strategy Systematic experimentation, which was the strategy most frequently used by pupils in the experiment, and the dangers its use represents to pupils.

(Novotná et al., 2014) describes the strategies Analogy, Guess – check – revise, Systematic experimentation, Problem reformulation, Solution drawing, Working backwards and Use of graphs of functions only briefly. In this paper, the types of problems that can be solved efficiently using these strategies and the potential dangers a pupil must face when using the strategies are illustrated on real problems. A detailed description of the five strategies that were used in the four-month-experiment is presented below. This will allow the reader to grasp the core of the different strategies.

Materials and Methods

11 teaching experiments were conducted in 11 lower and upper secondary schools in North Bohemia in the years 2012 and 2013. 4 experiments were conducted with 12-year-old pupils, 4 experiments with 14-year-old pupils and 3 experiments with 17-year-old students. All the selected schools were ordinary schools without any specialization (basic schools in case of 12 and 14 year old pupils and upper secondary grammar schools in case of 17 year old pupils). The classes were characterized as average or even slightly below average by their teachers.

In the period of four months, teachers of mathematics tried to teach their pupils to use two or three of the bellow listed heuristic strategies when solving mathematics problems.

Systematic experimentation

The principle behind this strategy is the idea that the result may be reached in a finite number of attempts. These attempts are carried out systematically. Each subsequent attempt will be "slightly" modified with respect to the previous one. The principle is based on the fact that the solver selects an initial value and then gradually gets nearer to the sought solution. This strategy seems to be very efficient in connection with the use of technological devices as these make it possible to conduct the experiments in real time. The use of computer in systematic experimentation is sometimes referred to as the use of "brute" force. The solution by brute force is specified as exhausting all single possibilities from the set of all potential results. The specification allows us to classify the presented illustrative problems into the following categories:

1. Problems solved using brute force (exploring all the possibilities).
2. Problems solved using brute force with justified termination of the experiment (exploring only a selected subset of all possible solutions).

A specific group is formed by problems in which

3. Systematic experimentation results in formulation or verification of some hypothesis.

Let us now illustrate the described strategy by one solution of a problem from each of the three above listed categories.

Problem 1

Assignment: Some tickets in a theatre were sold for 220 CZK and some at the price of 160 CZK. How many tickets at each price were sold if the total sum of 97 tickets was 19 300 CZK?

Solution: A spreadsheet will be used for experimenting. As mentioned above there are two possibilities. The first one starts as follows (see Table 1):

Number of tickets at 220 CZK	Price in CZK	Number of tickets at 160 CZK	Price in CZK	Total price in CZK
97	21340	0	0	21340

Table 1: Starting the first possibility for experimenting

and the other starts by a well-founded estimation (see Table 2).

Number of tickets at 220 CZK	Price in CZK	Number of tickets at 160 CZK	Price in CZK	Total price in CZK
65	14300	32	5120	19420
64	14080	33	5280	19360
63	**13860**	**34**	**5440**	**19300**
62	13640	35	5600	19240
…	…	…	…	…
1	220	96	15360	15580
0	0	97	15520	15520

Table 2: Starting with well-founded estimation

Some of the pupils were able to stop experimenting in a qualified way exactly at the place where is stopped being meaningful (see Table 3):

Number of tickets at 220 CZK	Price in CZK	Number of tickets at 160 CZK	Price in CZK	Total price in CZK
65	14300	32	5120	19420
64	14080	33	5280	19360
63	**13860**	**34**	**5440**	**19300**
62	13640	35	5600	19240

Table 3: Qualified termination of experimenting

Answer: 63 tickets at the price of 220 CZK and 34 tickets the price of 160 CZK were sold in the theatre.

Let us now discuss two problems from category 3 above, i.e. problems where systematic experimentation results in verification of a hypothesis.

Problem 2

Assignment: The numbers that are read the same from left to right and right to left, e.g. 452 254, are called palindromes. My friend claims that all four digit palindromes are divisible by 11. Is it true?

Solution: Palindromes are e.g. numbers: 127 721, 94 749, 8 338, 565, 44, 8. In the task, we are only interested in four digit numbers such as 6 776, 1 001, 2 992. Let us now take several four digit palindromes at random and divide them by eleven. We will get e.g. the following:

$$4\,554 = 414 \times 11$$
$$1\,001 = 91 \times 11$$
$$8\,338 = 758 \times 11$$

It seems my friend could be right. However, we will not be one hundred percent sure unless we check all the 90 existing four digit palindromes. This can be done efficiently using a spreadsheet (see Table 4).

a	*b*	"=b2"	"=a2"	"=1000*A2+100*B2 +10*C2+1*D2"	"=E2/11"
1	0	0	1	1 001	91
1	1	1	1	1 111	101
…	…	…	…	…	…
2	9	9	2	2 992	272
…	…	…	…	…	…
9	1	1	9	9 119	829
…	…	…	…	…	…
9	9	9	9	9 999	909

Table 4: Use of spreadsheet for Problem 2

The last column shows that all quotients are whole numbers.

Answer: My friend was right.

In contrast, the use of spreadsheet can result in rejection of the hypothesis.

Problem 3

Assignment: Decide if the sequence $x_n = \frac{20^n}{n!}$ is monotonous.

Solution: Let us determine the first few members of the sequence x_n.

$$x_1 = 20$$
$$x_2 = 200$$
$$x_3 = 1\,333.3\ldots$$
$$x_4 = 6\,666.6\ldots$$

The natural hypothesis is that the sequence x_n is increasing. Most pupils will come to this conclusion without hesitation.

Now it is the teacher's turn to remind pupils of the definition of an increasing sequence and to make pupils consider whether the conclusion they came to really corresponds to the condition in the definition that inequality $x_n < x_{n+1}$ holds for all natural numbers n. Only very few pupils will be able to realize at this point that it is not the case. However, using a spreadsheet they will see it all at once (see Table 5).

n	x_n
1	20.0
2	200.0
3	1 333.3
...	...
17	36 850 332.5
18	40 944 813.9
19	43 099 804.1
20	43 099 804.1
21	41 047 432.5
22	37 315 847.7
23	32 448 563.2
...	...

Table 5: Use of spreadsheet for Problem 3

Answer: It is obvious that the sequence x_n is not monotonous. The member $x_{19} = x_{20}$ and the following members are decreasing.

Guess – check – revise

This strategy, similarly to the above discussed strategy, is from the family of experimental strategies. Its principle is very simple: we guess a solution, check it and make a new guess on the basis of the previous result. E.g. if a pupil is carrying out "manual" division of a multi digit number by a two digit number, he/she is using this strategy. At first he/she guesses how many times the divisor is present in the dividend and then checks this guess by calculation. If the estimation was not correct, he/she makes a new guess taking into account the previous unsuccessful guess and carries on in the same way. This practice of an important heuristic strategy is the reason why manual division should remain part of school mathematics even at the time of calculators and computers.

In case of arithmetic problems it is very convenient to record the results in a table. If there is a pattern or regularity pointing at a result it is more likely to be discernible in a table. The idea of the use of this strategy in arithmetic problems is pretty obvious. That is why we will illustrate this strategy on "graphic" solving procedures that are less common but may be much more efficient. Let us now illustrate the described strategy by two problems.

Problem 4

Assignment: There are two balls on a billiard table. Determine the place on the edge of the billiard table in such a way that the ball *A* caroms ball *B* in one rebound.

Solution: Experimenting is conducted using the GeoGebra. Figure 1 illustrates the situation from the assignment. The illustration may be created by the solver on his/her own if they know the principles of reflection or may be prepared by the author of the problem. Then the illustration may be an applet on a website and can be opened on the solver's device and experimented with.

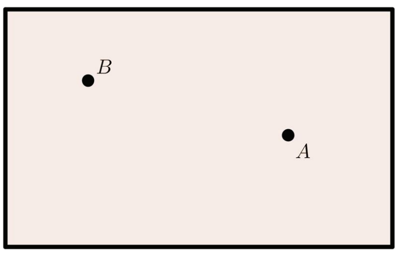

Figure 1: Situation from the assignment

If we move the point on the edge of the table we will gradually arrive at the right solution (see Fig. 2). It follows a number of guesses only one of which is right (with respect to one edge).

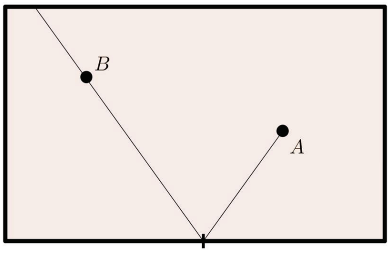

Figure 2: Moving the point on the edge of the table

Animated movement representing the rolling ball (represented by smaller point – see Fig. 3) is also possible.

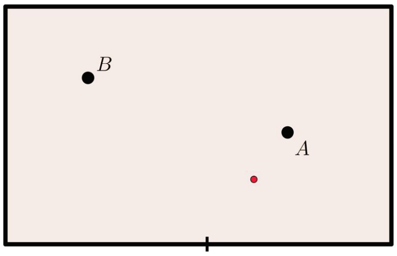

Figure 3: Animated movement

As soon as the pupil experimentally determines the right place on the edge of the table (let us call it point C – see Fig. 4), he/she can start thinking about the situation. The existence of four possible solutions – one for each edge – gives him/her insight into the situation from more points of view. This will be most illustrative if points A, C and B, C are connected by straight lines p and q.

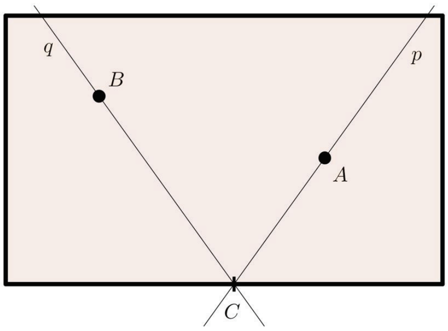

Figure 4: Finding the point *C*

We know that any two intersecting lines have two lines of symmetry (see Fig. 5).

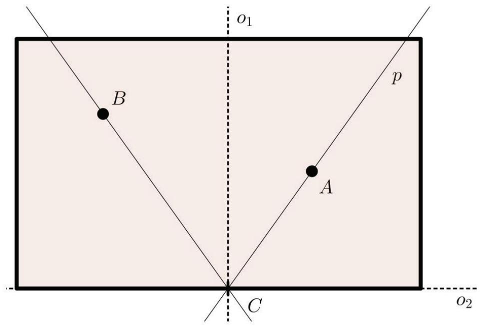

Figure 5: Lines of symmetry

The vertical line of symmetry o_1 represents the principle of reflection, the horizontal line o_2 allows us to solve the task. What we have to do is find the reflection of point B in line symmetry o_2. The connecting line of points B' and A intersects the edge of the table in the sought point C (see Fig. 6).

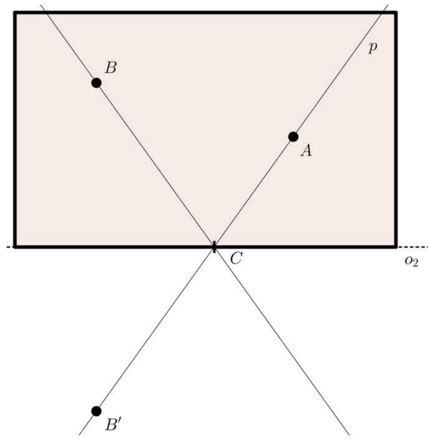

Figure 6: Finding the point *B'*

Experimenting helped us not only find the sought point but also the idea how to construct the sought point.

Answer: Point C obtained as described above is the place we were looking for.

Problem 5

Assignment: An employee's monthly salary was 15 755 CZK. During the year he got a pay raise of 2 100 CZK. Since which month was his income higher if his yearly income was 195 360 CZK?

Solution: Let us solve the problem by experimenting with the use of spreadsheet (see Tab. 6). Let us make a first guess and give the employee the pay raise in June (the third row in the table). The annual income is then higher than in the assignment. Let us try to give him the pay raise later – in November (the fourth row in the table). That is too little. So now, we can try to give him the pay raise in the tenth month (the fifth row in Table 6). Thus we got the requested income.

	Original income	Income after pay raise	Annual income
	15 755	17 855	195 360
Number of months	5	7	203 760
	10	2	193 260
	9	3	**195 360**

Table 6: Use of spreadsheet for Problem 5

Answer: The employee got the pay raise in October.

Working backwards

This is a very common strategy in mathematics. We assume that what we have to find/prove/construct holds/exists. Then we try to deduce from this assumption something we already know or something that is easy to prove/calculate/construct. Thus we in fact try to get from the end to the starting situation as close as possible. The procedure is reverted in the final calculation/proof/construction. Let us now illustrate the described strategy by two problems.

Problem 6

Assignment: There are 16 matches in pile. Two players take turns to take one or two matches from the pile. The winner is the player who takes the last one or two matches. Find the winning strategy for the first player. (A winning strategy is a strategy which, if used by the player, results in victory of the player regardless of the moves of the opponent).

Solution: Let us proceed from the end of the game: If one of the players (let us call him/her A) manages to arrange that his/

her opponent (let us call him/her *B*) must play when there are 3 matches in the pile, *A* will be the winner. Three matches in the pile are the closer target. Let us continue. If player *A* manages to arrange that it is player *B*'s turn when there are 6 matches in the pile, he/she will be the winner. Thus six matches in the pile after player *A*'s turn is the new closer target. And analogically: even closer targets of the winning strategy are 9, 12, 15. So if the first player plays in a way that after his/her move that are the following numbers of matches in the pile - 15, 12, 9, 6, 3, he/she will be the winner.

Answer: If the first player first takes way one match and then plays in such a way that there are 15, 12, 9, 6, 3 matches after his/her move, he/she will be the winner.

Problem 7

Assignment: I am thinking of a number. If I add 300 and subtract 165, I get a number which is five times greater than number 79. Which number am I thinking of?

Solution: Let us first calculate the number we are meant to get to following the instructions:

$$5 \text{ x } 79 = 375.$$

Now we will carry out inverse operations to the operations from the assignment:

$$395 + 165 - 300 = 260.$$

Answer: The number is 260.

Introduction of an auxiliary element

The basic idea of this strategy is that the introduction of the so called auxiliary element makes the solution more easily accessible to the solver. In accordance with (Polya, 2004) we define an auxiliary element as an object that is not explicitly present in the problem assignment and that we introduce into the problem, hoping it will help us see the solution more easily. Polya calls this strategy Auxiliary elements and understands it in a broader context than as we present it because we focus exclusively on school problems. Introduction of an auxiliary element usually means adding lines, line segments, circular arcs or other geometrical figures. In case of algebraic problems we usually add a convenient number to both sides of the equation or we introduce a new unknown. As this element is not explicitly present in the problem assignment and we introduce it into it, we call this type of solution the strategy of Introduction of an auxiliary element. This strategy is very common in school mathematics and we are often not aware we are actually using it. Let us now illustrate the described strategy by two problems.

Problem 8

Assignment: Let p be a prime number greater than 3. Prove that number $p^2 - 1$ is always divisible by the number 24.

Solution: Let us first decompose the given quadratic binomial

$$p^2 - 1 = (p - 1)(p + 1).$$

Then let us insert number between numbers and (p is our auxiliary element). Let us now consider the triplet of numbers

$$p - 1, p, p + 1.$$

They are three consecutive natural numbers. Thus one of them must be divisible by 3. The prime number cannot be divisible by three. Therefore it is either or, which is divisible by 3. Since numbers and are both even (the only even prime number is 2), they are both divisible by 2 and one must even be divisible by 4. Therefore the product

$$(p - 1)(p + 1)$$

must be divisible by the product of number 3, 2 and 4, i.e. the number 24.

Problem 9

Assignment: Given is a convex quadrilateral $ABCD$, see Fig. 7. Join midpoints M, N of the sides AD and BC. Determine the relation between $|MN|$ and $\frac{1}{2}(|AB| + |CD|)$.

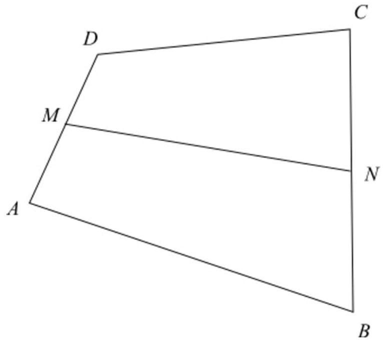

Figure 7: Quadrilateral *ABCD*

Solution: Let us introduce an auxiliary element into the assignment. Let this element be the diagonal *BD* (see Fig. 8).

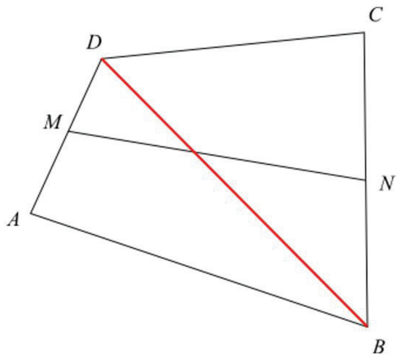

Figure 8: Used auxiliary element

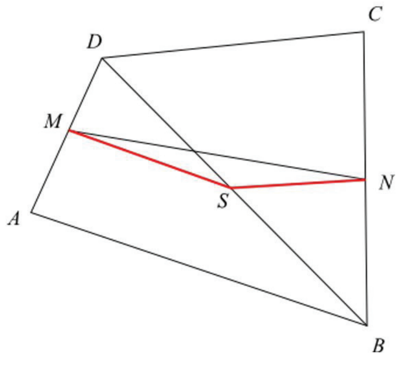

Figure 9: Triangles *ABD* and *CDB*

Let us now focus on the situation in the created triangles. If we construct the midpoint S on the diagonal BD, then the line segments MS and NS are the midlines of the triangles ABD and CDB respectively (see Fig. 9). Thus it holds that

$$|MS| = \frac{1}{2}|AB|,$$
$$|NS| = \frac{1}{2}|CD|.$$

Applying triangle inequality to the triangle SNM we get:

$$|MN| < |MS| + |NS| = \frac{1}{2}|AB| + \frac{1}{2}|CD| = \frac{1}{2}(|AB| + |CD|).$$

Note: It is obvious that the relationship of equality comes when the point S (the midpoint of diagonal BD) is on the line segment MN, i.e. in case that $ABCD$ is a trapezium.

Answer: It holds in any convex quadrangular $ABCD$, whose midpoints of the sides AD and BC are M and N respectively:

$$|MN| \leq \frac{1}{2}(|AB| + |CD|).$$

Omitting a condition

Problem assignment often involves several conditions. If we are not able to fulfill all these conditions when solving the problem at once, we can ask similarly to Zeitz (2007): What is it that makes the solution of this problem so difficult? If we manage to identify which of the initial conditions is the difficult one, we can try to omit it. If we are then able to solve the simplified problem, we can go back to the omitted condition and try to finish solution of the original problem. Let us now illustrate the described strategy by two problems.

Problem 10

Assignment: Construct a rectangle $ABCD$, where the ratio of the sides is 3 : 2 and whose diagonal is 7 cm long.

Solution: If we omit the condition that "its diagonal is 7 cm long", we get a very simple problem. We construct the rectangle $AKLM$, whose sides are e.g. 3 cm and 2 cm (see Fig. 10). The assigned rectangle is an enlargement of the constructed rectangle with the centre A (see Fig. 11). The vertex C must lie on the ray AL in the distance of 7 cm from the vertex A. The following construction is obvious.

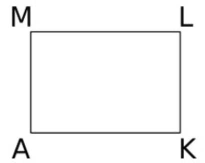

Figure 10: Rectangle *AKLM*

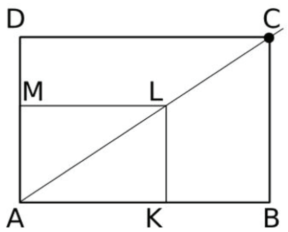

Figure 11: Enlargement with the centre *A*

Problem 11

Assignment: Given are a classical chessboard from which two opposite corner black fields have been cut off (see Fig. 12) and a sufficient number of domino tiles. Is it possible to cover this cut off chessboard with domino tiles in such a way that none of them sticks out of the board?

Solution: Let us omit the condition that the two fields have been cut off and let us work with a classical chessboard of 64 fields. It is relatively easy to cover this chessboard with domino tiles. Let us now return to the omitted condition – let us cut off the two opposite corner black fields from the (covered) chessboard. Obviously together with the two fields also two domino tiles will be removed and two white fields will remain uncovered. As each tile can only cover one black and one white field, the two remaining white fields obviously cannot be covered with a domino tile however we place the other domino tiles.

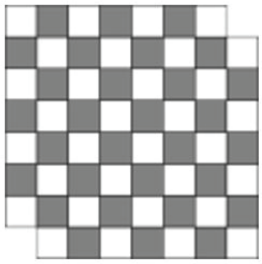

Figure 12: The given board

Answer: The cut off chessboard cannot be covered with domino tiles.

While strategies Introduction of an auxiliary element and Omitting a condition require creative activity from the solver and depend on the solved problem, the first three strategies can be characterized as strategies of algorithmic nature and pupils can use them successfully even if they do not have very good insight into the structure of the problem; use of these strategies does not always ask for very active involvement of pupils' creativity.

The participating teachers were provided with a sufficient number of problems that are solved most efficiently using one of the above listed strategies.

The teachers' work was organized as follows. They assigned a problem to their pupils. They let them work and asked the pupil who was the fastest to solve the problem correctly to explain their solution to the others. This was followed by a discussion and explanation of the solving strategy. The teacher then asked other successful solvers to present alternative solutions to the others. If none of the pupils solved the problem with the intended heuristic strategy, it was demonstrated by the teacher. In another, similar problem the teacher then checked to what extent the teacher's solution was actively understood.

Every teacher solved in this way about three problems a week. The pupils sat a written pre-test and post-test at the beginning and the end of the experiment. The problems in the test were the same. Each test consisted of four tasks which were about equally as difficult as problems solved during the teaching experiment. All the problems in the test shared one feature. The selected heuristic strategy was the most efficient way of solving the problem. When evaluating the written tests, attention was paid to success rate but also to the method of solution, i.e. also whether the pupils used some of the strategies shown in the teaching experiment.

Results and Discussion

Research questions

1. Is it possible to achieve any progress in the ability to solve mathematical problems using the strategies Introduction of an auxiliary element and Omitting a condition for a short period of time (4 months) or do they make their "implantation" in such a short period of time impossible?
2. The strategy that seemed as the most easily usable in the experiment was Systematic experimentation (see Novotná et al., 2014). Does its frequent use by pupils have only positive consequences, or does it bear any potential risks? If so, which?

Results

Because of the limited scope of the paper, we have chosen one or two problems from a test in each age category which we present and comment upon.

12-year-old pupils, 98 respondents in total:

Problem 1

Assignment: Inscribe a square $KLMN$ in a given triangle ABC (see Fig. 13). Two vertices (K, L) of the square should be on the base AB of the triangle, the two other vertices (M, N) of the square on the two other sides of the triangle, one on each. (Polya, 2004, p. 23)

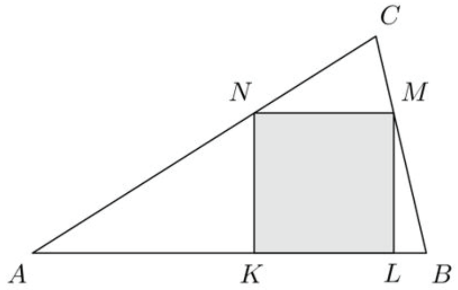

Figure 13: Assigned objects

Efficient solving strategy: Omitting a condition.

It is unlikely we succeed in constructing a square executing all conditions. If we drop the “the lies on the side” condition, we may find constructing such a $K_1L_1M_1N_1$ square with ease (see Fig. 14). We inscribe it in the BAC angle. The square we search is to be homothetic to that, with homothetic centre in the A point. The point M is the point of intersection of the ray AM_1 with the BC side.

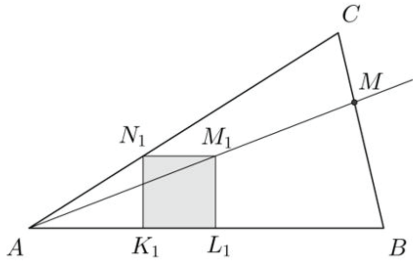

Figure 14: Constructing the square

Success rate in pre-test: 9%.

Success rate in post-test: 20%.

The number of pupils who used the strategy Omitting a condition in the pre-test: 9%.

The number of pupils who used the strategy Omitting a condition in the post-test: 20%.

Problem 2

Assignment: Determine the area of the kite whose measurements are given in Fig. 15. The data are given in centimeters.

Efficient solving strategy: Introduction of an auxiliary element.

We add diagonals into the kite figure (see Fig. 16) and use the formula for calculation of the area of a triangle. Let us use letters a, b, c in this order to label the sizes of the corresponding diagonals.

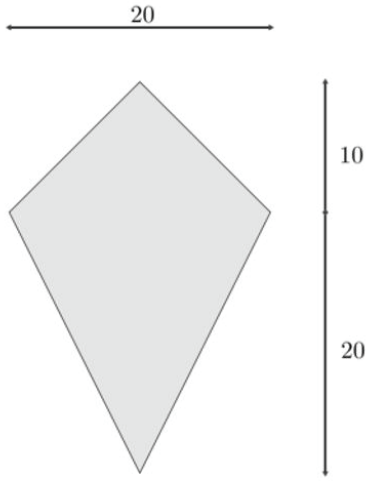

Figure 15: Figure assigned in Problem 2

$$S_1 = \frac{a \times b}{2}$$

$$S_2 = \frac{b \times c}{2}$$

$$S = 2S_1 + 2S_2$$

The answer is: We need 300 cm^2 of paper to create the kite.

Success rate in pre-test: 13%.

Success rate in post-test: 58%.

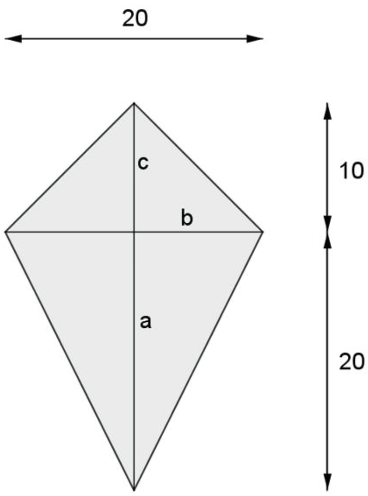

Figure 16: Auxiliary elements - diagonals

The number of pupils who used the strategy Introduction of an auxiliary element in the pre-test: 18%.

The number of pupils who used the strategy Introduction of an auxiliary element in the post-test: 74%.

14-year-old pupils, 109 respondents in total:

Problem 3

Assignment: Find two consecutive natural odd numbers whose product is 1023. (Cihlář, Zelenka, 1998, p. 89/12)

Efficient solving strategy: Systematic experimentation.

We select pairs of odd numbers in Table 7 and look for their product.

First odd number	Second odd number	Product of the numbers
1	3	3
3	5	15
5	7	35
7	9	63
9	11	99
11	13	143
13	15	195
15	17	255
17	19	323
19	21	399
21	23	483
23	25	575
25	27	675
27	29	783
29	31	899
31	**33**	**1023**

Table 7: Problem – Systematic experimentation

The answer is: The sought numbers are 31 and 33.

Success rate in pre-test: 21%.

Success rate in post-test: 54%.

The number of pupils who used the strategy Systematic experimentation in the pre-test: 0%.

The number of pupils who used the strategy Systematic experimentation in the post-test: 27%.

17-year-old pupils, 78 respondents in total:

Problem 4

Assignment: The perimeter of a rectangular garden is 114 m. One of its sides is 13 m longer than the other. Find the area of this garden.

Efficient solving strategy: Omitting a condition combined with Systematic experimentation.

Let us omit the explicitly stated condition that the perimeter of the garden is 114 m. Now we will use the strategy Systematic experimentation. Let us create a table whose first column represent length of side a, second column length of side $b = a + 13$, third column perimeter $P = 2(a + b)$ and fourth column area $S = ab$ (see Table 8). The table can be easily made e.g. in Excel, where after setting the formulae the program constructs the table within seconds.

a	b	P	S
1	14	30	14
2	15	34	30
…	…	…	…
21	34	110	714
22	**35**	**114**	**770**
23	36	118	828
…	…	…	…
44	57	202	2508

Table 8: Problem 4 – Omitting a condition combined with Systematic experimentation

If we reconsider the omitted condition we easily find the solution (it is highlighted in the table).

The answer is: The area of the garden is 770 m^2.

Success rate in pre-test: 27%.

Success rate in post-test: 39%.

The number of pupils who used the strategies Systematic experimentation and Omitting a condition in the pre-test: 0%.

The number of pupils who used the strategy Systematic experimentation and Omitting a condition in the post-test: 15%.

In the pre-test, successful students solved it exclusively using equations. However, although the problem is quite simple, many students failed to construct the equations correctly. In the post-test the number of successful solvers increased by students who combined strategies Omitting a condition and Systematic experimentation. Most of the pupils using combination of these strategies were successful.

Conclusion

The results of the experiment gained from the pre-tests and post-tests as well as from interviews with participating teachers allow us to formulate the following conclusions:

Experimental strategies (Guess – check – revise, Systematic experimentation) and the strategy Introduction of an auxiliary element can be mastered already in shorter period of time, the strategy Omitting a condition requires longer time. This is caused by algorithmic nature of the two experimental strategies (Novotná et al., 2014). As far as the strategy Introduction of an auxiliary element is concerned, the pupils were quite fast to learn to add different auxiliary elements into the drawing, not to give up solving the problem, to experiment.

The danger of Systematic experimentation is that its mastery by some pupils makes them use it as first solving procedure instead of e.g. constructing equation or system of equations. On the other hand, more frequent use of the strategy Systematic experimentation develops pupils' sense of effective choice of the initial value.

The short period of time of the experiment was sufficient to change attitudes of some pupils and students to problem solving (this could usually be observed in about one half of the pupils and students in each class). Pupils and students stopped being afraid of solving problems, they stopped laying their solution aside if they were not sure how to solve them in the very beginning. They learned to look for a solution rather than to give up.

Some teachers (about one third) claim that thanks to this experiment the ability to express ideas improved in about one half of their pupils or students. This is confirmed by the fact that pupils and students tend to comment on their solutions in more detail in the post-tests, more of them try to justify the individual steps in their solving procedure.

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ANALYSIS OF DEPENDENCES OF E-LEARNING USAGE ON STUDY RESULTS

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Highlights

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

Abstract

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

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Introduction

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

Internet usage for learning and e-learning was widely spread in 1990s as WBT (Web Based Training). It was necessary to offer materials for studying. Moreover, for the necessity to manage on-line materials, new system was created. This system is known as Learning Management System (LMS) and is still used. Some of the LMS are prepared as open-source (Moodle), some are on commercial base - Edovo, UNIFOR, iTutor, Eden, eDoceo (Blahoz, 2013; Majerova, 2012). E-learning started to be integrated into the university education in the Czech Republic since 1999 at the University of Ostrava (Poulova, 2010). Since 2003 all Czech universities (except of art ones – such as Acadamy of Performing Arts in Prague, Academy of Fine Arts in Prague, Janáček Academy of Music and Performing Arts in Brno, Academy of Arts Architecture and Design in Prague) have been using some types of LMS systems. Nowadays, most of the Czech public universities and colleges (or so-called HEIs – Higher Education Institutions) use the LMS Moodle.

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

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

- H_0: There is no significant dependence between study results and study field (tested for particular subjects)
- H_0: There is no significant dependence between full- and part-time students´ study results.

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

Materials and Methods

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1. H_0: There is no significant dependence between study results and selected years for particular subjects.
2. H_0: There is no significant dependence between study results and study field (tested for particular subjects)
3. H_0: There is no significant dependence between full- and part-time students´ study results.

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

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

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

Number of students that studied these subjects is in Tab. 14. Mathematics I was studied in the first semester, Mathematics II in the second semester, Mathematics for Economists and Probability and Statistics in third semester, Statistical Methods in fourth semester of bachelor study. That is why the numbers of students are falling down from MAT1 to STM as some of the students leave the college without finishing the study. From the 3 mathematical subjects the most difficult seems to be MAT1 (according to the opinion of teachers and according to the marks – Tab. 15).This is one of the reasons for some students to leave the school and do not finish this subjects – see Tab.15 where more than 60% of part-time students and more that 40% at full time had "F" grade from IS so they did not try any exam (if they tried and failed they get "F" from the teacher not from the IS). MAT2 and MATE were also difficult as the % of "F from IS" together with "F" is also high (Tab. 16, Tab. 17) but more students have "F" given by the teacher so they tried to pass the exam. The situation with PS subject is similar to MATE as a lot of student obtained "F" from the teacher and only a few of them (except of the year 2012) gave up the subject.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- H_0: There is no significant dependence between study results and selected years for particular subjects.
- H_0: There is no significant dependence between full- and part-time students´ study results.

Results

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

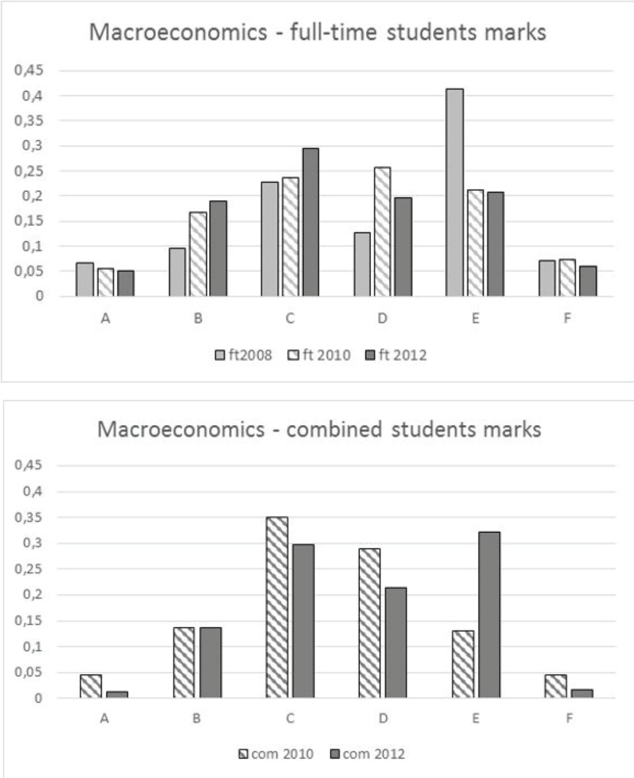


Figure 1: Macroeconomics – comparison of results (% of students with given mark), source: own calculations

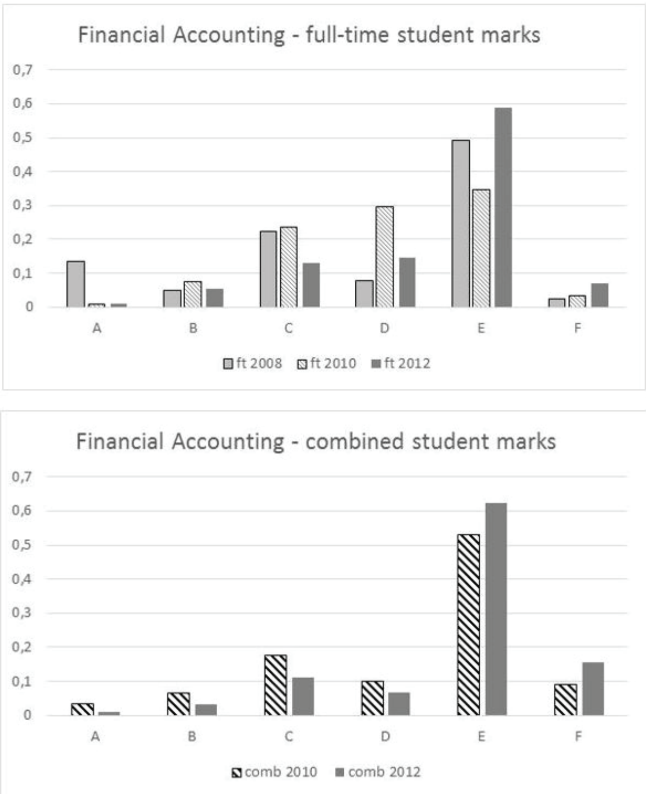


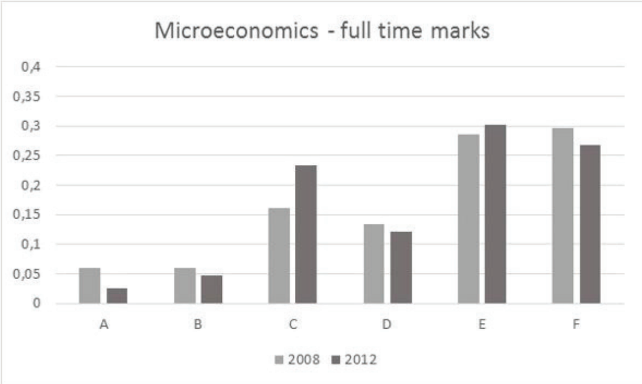
Figure 2: Financial Accounting – comparison of results (% of students with given mark), source: own calculations

We calculated also the average marks just to see the differences in this mean value for the selected subject during years and for the study fields and type of study. For the calculations mark "A" is equal to 1, "B" = 1.5, "C" = 2, "D" = 2.5, "E" = 3 and "F" = 4 (this is given by the rules of the college, these numbers are used for the average marks calculation). Based on the fact that we do not have continuous data set and the normality was not proven for all the subjects by the normality test, the calculated F-test (showing the equality/inequality of the variances of two data sets) and two sample t-test (showing equality/inequality of the means) must be taken with circumspection only as complement to the Chi-square test results.

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

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

Table 20: Dependence on the year (deg. of freedom=5; critical Chi-value=11.07) and average marks, source: own calculations



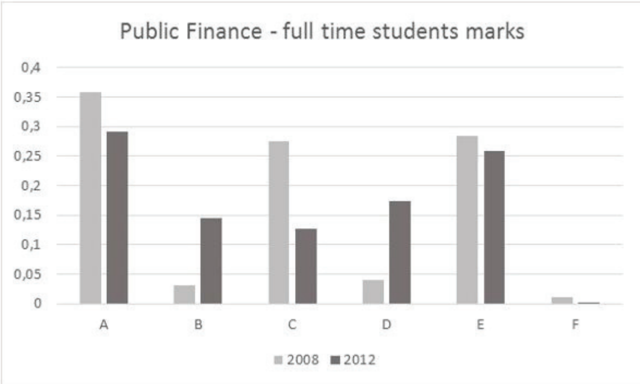


Figure 3: Microeconomics and Public Finance – comparison of relative frequencies of results (% of students with given mark), source: own calculations

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

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

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

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

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

	p-value Chi-test (p-value t-test), (p-value F-test)		Average marks (full time students)			
subject / years	2008 TT/FM	2012 TT/FM	2008 TT	2008 FM	2012 TT	2012 FM
BE	0.07366	0.32075	2.59570	2.34507	2.75632	2.76506
	(0.00), (0,01)	(0.82), (0,24)				
MAE	0.52413	0.16283	2.44958	2.58389	2.20918	2.38235
	(0.09), (0,74)	(0.03), (0.46)				
MGA	0.10218	0.26220	2.10536	2.32095	2.00189	2.08383
	(0.01), (0.90)	(0.30), (0.05)				
MIE	0.00000	0.08931	2.81225	2.89808	2.88095	2.80201
	(0.29), (0,01)	(0.38), (0.55)				
FIA	0.00022	0.91254	2.30819	2.58599	2.76364	2.76301
	(0.00), (0.06)	(0.99), (0.72)				
PF	0.20556	0.63099	1.87393	2.07692	1.94748	2.04575
	(0.02), (0.85)	(0.24), (0.83)				

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

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

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

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

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

Table 23: Dependence on the type of study ((deg. of freedom=5; critical Chi-value=11.07) and average marks (full time, combined students), source: own calculations

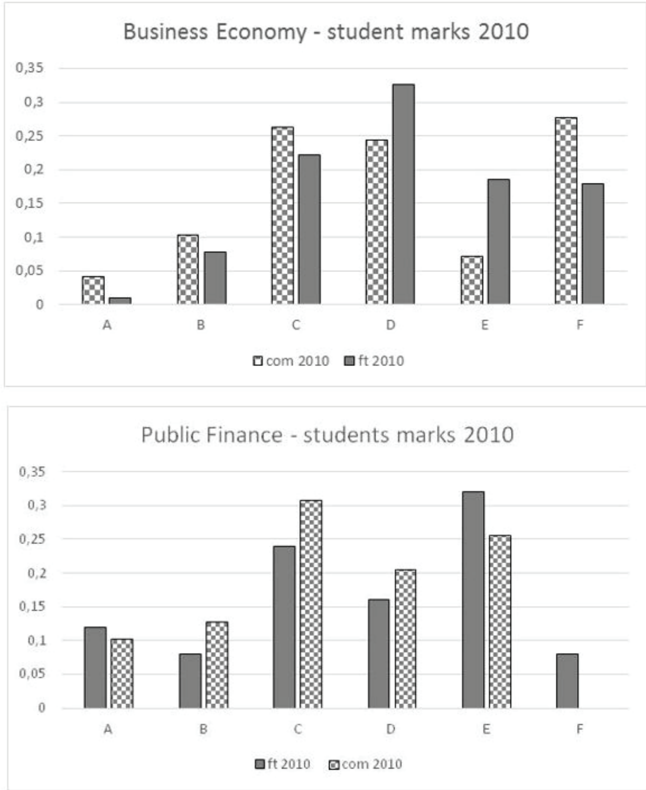


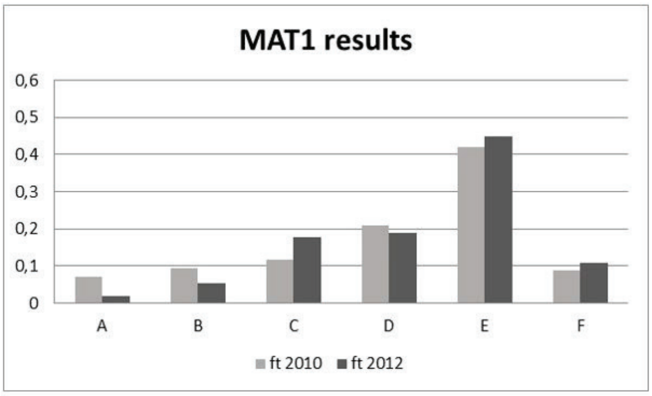
Figure 4: Business Economy and Public Finance – comparison of results (% of students with given mark), source: own calculation

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

	p-value Chi-test (p-value t-test), (p-value F--test)		Average marks (full time students)		
subject / years	2008/2012	2010/2012	2008	2010	2012
MAT1	0.00000	0.13656	2.2245	2.5848	2.7143
	(0.00), (0.04)	(0.11), (0.15)			
MAT2	0.00001	0.04929	2.6375	2.5167	2.2805
	(0.04), (0.03)	(0.50), (0.95)			
MATE	0.00000	0.01016	2.2750	2.7039	2.4669
	(0.05), (0.01)	(0.02), (0.29)			
PS	0.00000	0.80702	2.2177	2.8528	2.8386
	(0.02), (0.83)	(0.85), (0.39)			
STM	0.00000	0.00000	2.1429	2.2826	2.5621
	(0.00), (0.00)	(0.00), (0.22)			

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

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



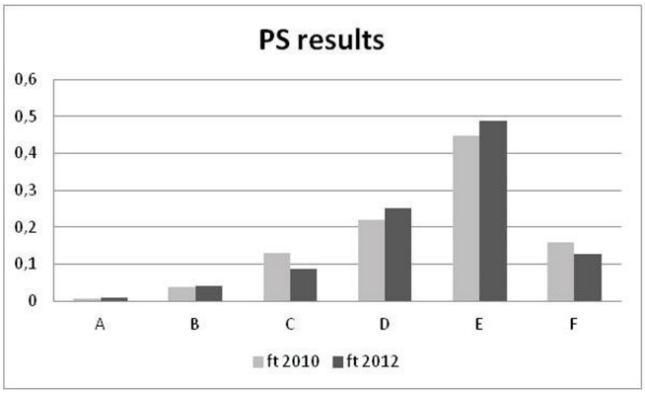


Figure 5: Mathematic 1 and Probability and Statistics – comparison of results of full-time students (% of students with given mark), source: own calculations

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

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

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

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

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

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

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

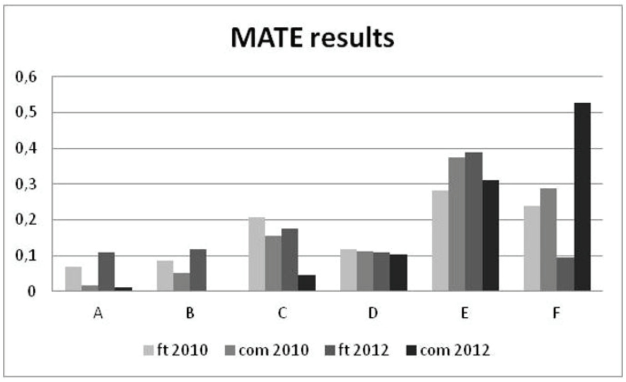


Figure 6: Mathematic for Economist – comparison of results of full-time and combined form students (% of students with given mark), source: own calculation

Discussion

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

Conclusion

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

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- Hana Chylova, Department of Psychology, CULS Prague
- Ludmila Domeova, Department of Systems Engineering, CULS Prague
- Jiri Fejfar, Department of Systems Engineering, CULS Prague
- Martina Fejfarova, Department of Management, CULS Prague
- Tomas Hlavsa, Department of Statistics, CULS Prague
- Martina Houskova Berankova, Department of Systems Engineering, CULS Prague
- Jakub Husak, Department of Humanities, CULS Prague
- Martina Kuncova, Department of Economic Studies, College of Polytechnics Jihlava
- Petr Kucera, Department of Systems Engineering, CULS Prague
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- Hana Urbancova, Department of Management, CULS Prague
- Eva Vaneckova
- Kristyna Vltavska, Department of Economic Statistics, University of Economics, Prague
- Zdenka Zakova Kroupova, Department of Economics, CULS Prague

Complete information regarding to this conference is available at the conference website http://erie.pef.czu.cz or you can contact us via the email address erie@pef.czu.cz.

Keynote speaker

Anna Croon Fors

Since 2013 Assoc. Prof. Anna Croon Fors holds the chair of Umea Center for Gender Studies, Umea University, Sweden. She also holds a position as an Associate Professor at the Department of Informatics at the same university. She received a PhD in Informatics from the Department of Informatics, Umea University, Sweden, and was appointed Head of the same department from 2007-2010.

Croon Fors has more than twenty years of experience in teaching, academic leadership, and collaboration with industrial, governmental and non-profit organizations. Her engagement in research, research education, and teaching in higher education is dedicated to alternative forms of knowledge production with respect to societal challenges, and the interdisciplinary/transdisciplinary work required addressing them.

Divergent and evolving societal needs make new demands regarding knowledge production, forms of organization, and alliances in relation to research, education, and infrastructures. These challenges have long been at the heart of Croon Fors' academic work. In particular, she focuses on the ways in which the approaches of systems thinking, design theory and feminist technosciensce can be used to privilege situated knowledge, alternative visions and new compositions, providing a sharp contrast to traditional views within science and engineering research and education. Her work is dedicated to envisioning alternative platforms for knowledge production and contestation that are ultimately capable of producing new realities.

Conference Fee

- Full conference fee: 140 EUR or 3800 CZK
- Reduced conference fee (for regular PhD students): 80 EUR or 2200 CZK

Conference deadlines

- 6th January, 2015 - 1st call for papers
- 2nd February, 2015 – 2nd call for papers
- 2nd March, 2015 – Deadline for full paper submission
- 13th April, 2015 – Results of review process
- 1st May, 2015 – Deadline for final version submission
- 10th May, 2015 – Notification of paper acceptance
- 18th May, 2015 – Deadline for conference fee payment