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JOURNAL ON EFFICIENCY AND RESPONSIBILITY IN EDUCATION AND SCIENCE

Aims and Scope

The Journal on Efficiency and Responsibility in Education and Science aims to publish perspectives of authors dealing with issues of efficiency and/or responsibility in education and related scientific disciplines. The focus is on topics such as:

- theory and methodology of pedagogy and education;
- theory and methodology of science;
- human resources and human relations management;
- knowledge management and knowledge engineering;
- systems engineering and information engineering;
- quantitative methods.

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ANALYSIS OF SUBJECT DISCRETE MATHEMATICS PARTS AND PROPOSAL OF E-COURSE MODEL FOLLOWING PETRINETS FOR INFORMATICS EDUCATION

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Abstract

Nowadays, quality Mathematical basis - Informatics is an inherent part of study. Mathematical basis is provided by Discrete Mathematics that is taught as a compulsory subject in stated study program in the Department of Mathematics. Authors clarify significance and importance of simple thematic units of subject Discrete Mathematics in teaching technical - system subjects in study programme Applied Informatics. Mentioned subject is being taught in first year of University study and knowledge that students acquire during the study of this course are the "cornerstone" for their further development in technical - system study. Justness and importance of individual topics were analysed based on the evaluation of questionnaires, in which pedagogues teaching profession al IT subjects alloted weighted coefficients to individual thematic units. Weighted coefficients were alloted based on the significance of the given topic of the subject Discrete Math, with regard to the IT subject they are teaching. Upon designing the e-course, experience with the creation of linear and branch teaching software were used. For the simulation of the transition of students through individual lessons as well as the whole course, authors employed the method of the teaching process simulation using Petri nets.

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Introduction

Significance of Mathematical support of Informatics education is often depreciated by students and most of them take it lightly what influenced their next studies. When they realize this fact it is often too late. One of the factors that affect the knowledge is diversity of students which are coming to study Informatics. Another factor is the learning standards that are valid at secondary schools. These standards are obligatory, but each school has some operational area and therefore this should be adjusted. The result is that some thematic units are not known from students coming to University. These discrepancies were partly eliminated when Discrete Mathematics was integrated into compulsory subjects.

Discrete Mathematics deals especially with discrete (discontinuous) structures researching. According to high-powered use of computers by solving the difficulties and different types of tasks, Discrete Mathematics overreaches the ambit of discrete analysis and comprises also a number of constructive methods developed for first-hand use of computers. Discrete Mathematics is relatively separate part of Mathematics. The main attribute is confidentiality, i.e. opposite of coherence and in broader sense it covers also disciplines like Numbers theory, Algebra, Symbol logic, Combinatory, Chart theory, Set theory and many others, which started their biggest development in the middle of 20th Century which was well - known for computer development (Toman, 2008).

In the article, authors describe not only the analysis of current status Discrete Mathematics education, but also the justness of single thematic units of Discrete Mathematics for single subjects of study programme Applied Informatics/Bc. Authors proposed e-course structure and content of Discrete Mathematics from obtained results with Web 2 technology support.

To ensure effective students graduation through educational course was used simulation of student passing through e-course method by Petri nets.

Material and Methods

Analysis of the current state of teaching discrete math

Discrete Math is a rather new field of mathematics dealing with discrete mathematic structures, which can be characterized by whole (integral) numbers, and are thus „countable“. It is an opposite of mathematics, which deals with continuous structures characterized by real numbers, such as mathematic analysis. Development of discrete math was conditioned mainly by the development of informatics. In fact, discrete math is often understood as a part of informatics. Some mathematicians integrate only new mathematic disciplines, which originated in connection with the development of computer technology, into discrete math (Jablonski, 1982).

Discrete math is a standard component of education in informatics. The subject Discrete Math is an obligatory subject not only in study programmes of informatics fields of study in the Slovak and Czech Republic, but also in other countries, where Informatics is taught. This information was obtained through an analysis of web-sites of individual universities in Slovakia and abroad. An important form, which offered relevant information on the study of informatics, were information sheets of study programmes based on the contents of which it was necessary to compare individual thematic units of the subject and to find out to what extent they are consistent with the information sheet, according to which Discrete Math is taught at the Constantine the Philosopher University in Nitra, Slovakia.

Based on the obtained contents of information sheets of the subjects Discrete Math 1 and 2 it is possible to define the aim and content of subjects Discrete Math 1 (*DM1*) and Discrete Math 2 (*DM2*):

DM1

This discipline focuses on the complementation and enlarging of the concepts forming the mathematical basis of informatics. Its task is to retrace and deepen basic concepts from the sphere of arithmetic, theory of sets, sententional calculus and boolean calculus, which find wide application in all spheres of informatics (Tomanová and Vozár, 2006).

DM2

This discipline focuses on the complementation and enlarging of the concepts forming mathematic basis of informatics. Its task is to retrace and deepen basic concepts from the sphere of combinatorics and theory of graphs with the focus on graph algorithms. It is a continuation of the subject Discrete math 1 (Tomanová and Vozár, 2006).

Having finished the analysis carried out at all universities within the Slovak and Czech Republic, which offered the study field Applied Informatics, we focused our attention to four Slovak and three Czech u

niversities. The reason for this was to select adequate universities with a comparable focus and the study field/study programme mentioned above (Turčáni, Kuna, 2012).

Within the Slovak Republic the following universities were included:

- Constantine the Philosopher University in Nitra
- Comenius University in Bratislava
- Technical University in Košice
- Slovak Technical University in Bratislava

Within the Czech Republic the following universities were included:

- Ostrava university in Ostrava
- Charles University in Prague
- Masaryk University in Brno

Having compared individual thematic units of the subject Discrete Math within the selected universities in the Slovak and Czech Republic we found out that information sheets of the subjects Discrete Math 1, 2 are comparable and identical as to the contents. We can thus state that the teaching of the subject Discrete Math at the Faculty of Natural Sciences, Constantine the Philosopher University in Nitra is comparable with the ones at other universities.

Justness of individual topics of the subject discrete math for individual subjects of the study programme Applied informatics/Bc.

Identifying the justness of single thematic units which are taught on Informatics Department within mathematical base for individual subjects of study program Applied Informatics for bachelor degree was necessary to divide in two steps.

The first step by solving this issue was to find out the just ification of each thematic unit, which is being taught in Discrete Mathematics. Thematic units are specified in informational sheet of Discrete Mathematics. We compared the se units with thematic units of other Universities with similar focus. This analysis shows us that thematic units which are included into study are more or less the same as those taught at other.

We requested teachers of individual subjects from Informatics Department which was the second step for discovering the justness of single thematic units. Number of subjects which teachers evaluated by balance ratio was 19. Number of teachers involved in this research was 11. Number of thematic units for Discrete Mathematic subject 1 was 12 and for Discrete Mathematics 2 it was 11. The questionnaire was repeated two times according to Delphi method. Standard process of Delphi method is to request a group of teachers by questionnaires in the first round. Obtained data are being analyzed and statistical characteristics are being set (mainly median and quartile allowance). This conclusion is becoming a part of next questionnaire in the second round (Bílek, 2008).

The topics were taken over from information sheets for the subjects Discrete Math 1 and 2 for the study field Applied Informatics. The main task of the questionnaires was to find out the degree of importance and the meaning of thematic units of subjects Discrete Math 1 and Discrete Math 2 in the teaching of informatics study programmes.

The process of filling in the questionnaires took place at the Department of Informatics in the following stages:

- Selection of pedagogues (12 pedagogues participated in the interview),
- Comparison of answers; the most frequent proposals were marked in the second
- questionnaire,
- In the second round median was marked in the scale dispersion in the questionnaire,
- Pedagogues were submitted the adjusted questionnaire repeatedly and were asked to allot the weighted coefficient to individual thematic units,
- For the evaluation of the results of evaluation by pedagogues the Delphi method known also as the Delphi oracle was used. The Delphi method is a scheme of procedure of expert ´s answering aimed at activating the stimulation of expert ´s knowledge. The peculiarity, differentiating the method from expert´s interview, consists in the fact that the process of answering is recurrent. In individual interlocked cycles pedagogues are individually acquainted with the results of previous cycles by an independent person, and based on that they can modify their evaluation (Bílek, 2008),
- Arithmetic mean with the application of all answers was used for the evaluation. The resulting value was calculated by dividing the sum of all answers by N pedagogues.

Weighted coefficients (the sum of the first and second cycle in the questionnaire), which were allotted by pedagogues to individual thematic units from the subject DM1 regarding their subject being taught, are presented in Table 1. The values in line one - T1 through T12 in the table represent individual thematic units, which are taught within the subject Discrete Math 1. In the first column are presented abbreviations of subjects.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
AP1	10	9,5	7	6	10	10	10	5	4	3	6	8
AP2	10	9,5	7	6	10	10	10	5	4	3	6	8
OS1	4,5	6	8	8	9	8	9	6	5,5	2	7	6
OS2	4,5	6	8	8	9	8	9	6	5,5	2	7	6
PS1	3	3	5	6	5	5	4	2	2	2	4	5
PS2	3	3	3	4	7	6	2	6	6	2	7	7
KOD	10	8	6	6	8	4	8	10	8	4	8	4
PRO1	8	4	7	7	5	4	3	9	6	5	7	3
PRO2	7	4	6	6	5	4	2	6	5	4	6	4
PDA	6,5	3	8	5,5	5,5	5,5	2,5	2,5	3	2,5	4,5	4
DS	5,5	4	9	6	6,5	5	2,5	3	4	2	3,5	4,5
FJA	7	3	9,5	9	4	4	4	8,5	9	2	9	5
PG	7,5	6	7	6	5,5	5,5	6	7,5	7	3,5	9	5,5
PDM	2,5	2,5	6	4	3	3	2	2	2	2	4	4
UDM	2,5	2	6	4	3	3	2	4	2	2	3	3
TAZ	9	9,5	6	6	4	3	2	9	4	2	4	4
UI	10	5,5	9	7	9,5	6	4	4	3,5	3,5	4	4,5
IS	4,5	3	6	5	5	4,5	2,5	2,5	3	3	3,5	4,5
NMO	2,5	2	7	4	3	3	2	4	2	2	3	3
Total	**117,5**	**93,5**	**130,5**	**113,5**	**117**	**101,5**	**86,5**	**102**	**85,5**	**51,5**	**105,5**	**93**

Table 1: Weighted coefficient of thematic units in the subject DM1

It is obvious from the graphic illustration Figure 1 that pedagogues marked as the most important the thematic units topics T3 (Relation of divisibility and its attributes), T4 (The least common divider, the least common multiple, Euclid ´s algorithm), T1 (Basis of prepositional calculus), T5 (Diophant´s equations). This means that the given thematic unitsreached the highest weighted coefficient.

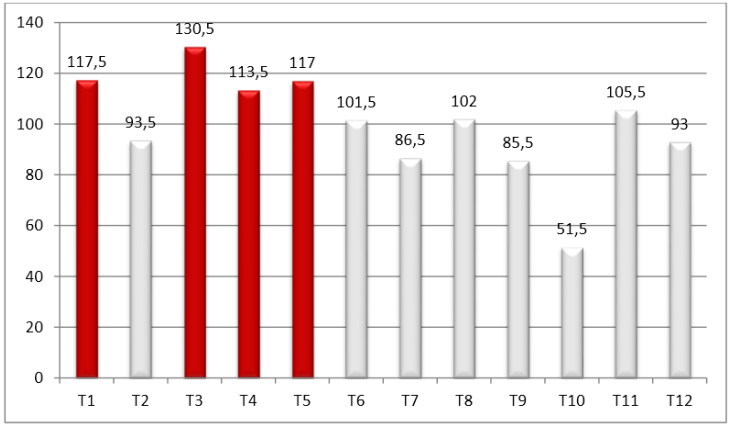

Figure 1: Graphic depiction of the evaluation of DM1

Weighted coefficients (the sum of the first and second cycle of the questionnaire), which were allotted to in dividual thematic units from the subject DM2 by pedagogues, regarding their subject taught, are presented in Table 2. The values in line one – T1 through T11 in the table represent individual thematic units, which are taught within the subject Discrete Math 2. In the first column are presented abbreviations of subjects.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
AP1	4	4	8	8	6	5	5	4	3	2	2
AP2	4	4	8	8	6	5	5	4	3	2	2
OS1	3	4,5	7	7,5	9	7,5	5	4	3,5	3	3
OS2	3	4,5	7	7,5	9	7,5	5	4	3,5	3	3
PS1	4	3,5	10	10	8	7	7	4	4	5	5
PS2	5	2,5	9	9	9	9	8	6	6	7	7
KOD	10	6	6	8	6	4	6	4	4	4	4
PRO1	8	7	10	6	5	5	4	3	3	3	3
PRO2	6	6	10	10	10	10	7	5	4	4	4
PDA	4	3,5	6	6,5	5,5	5,5	5	2,5	2	2	2,5
DS	3,5	3	6,5	6,5	6,5	6,5	6	2,5	2,5	2,5	2,5
FJA	4	2,5	5	4	7	2,5	4	2	2	2	2
PG	5,5	4,5	5,5	5,5	4,5	5,5	5,5	5	3,5	3,5	5
PDM	4	3,5	4,5	4	4	3	4	2,5	2	2	2
UDM	4	4	3	3	3	2,5	2	2	2	2	2
TAZ	10	2,5	10	10	10	10	10	10	10	10	10
UI	6	5	8,5	9,5	7,5	10	9	9	9	9	9
IS	4	3,5	4	4	4	4	3,5	2,5	2	2,5	3
NMO	4	6	3	3	3	2,5	2	2	2	2	2
Total	**96**	**80**	**131**	**130**	**123**	**112**	**103**	**78**	**71**	**70,5**	**73**

Table 2: Weighted coefficients of thematic units in the subject DM2

Values, which are presented in Table 2, are represented by Figure 2. The following topics were marked by pedagogues as the most important thematic units: T3 (Definition of the graph, the graph peak grade theorem, the theorem on the existence of the graph with the given grades of peaks, an algorithm for the finding out whether the given sequentiality is graphic), T4 (Continuity of the graph – sequence, route, trace, connection, course, the theorem on the number of sequences of the length between two peaks of the graph), T5 (Algorithm for the testing of graph continuity). This means that the given thematic units reached the highest weighted coefficient.

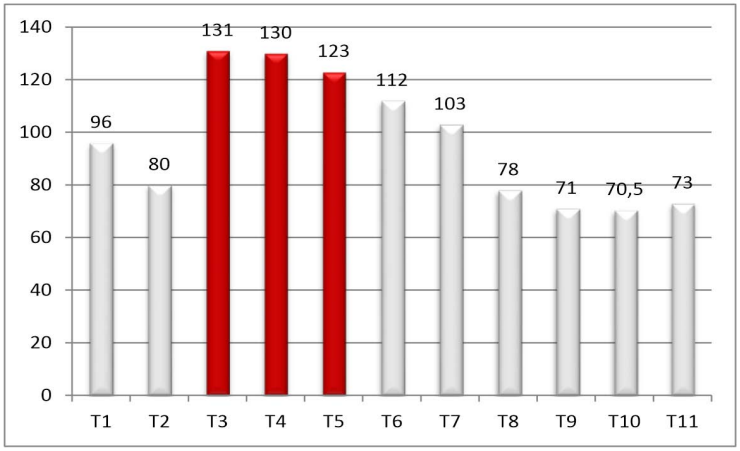

Figure 2: Graphic depiction of the evaluation of DM2

Results

To receive the final order, we need to create weight ratio total from first and second cycle. Final values of both cycles represents for the subject DM1 Figure 3 and for the subject DM2 Figure 4.

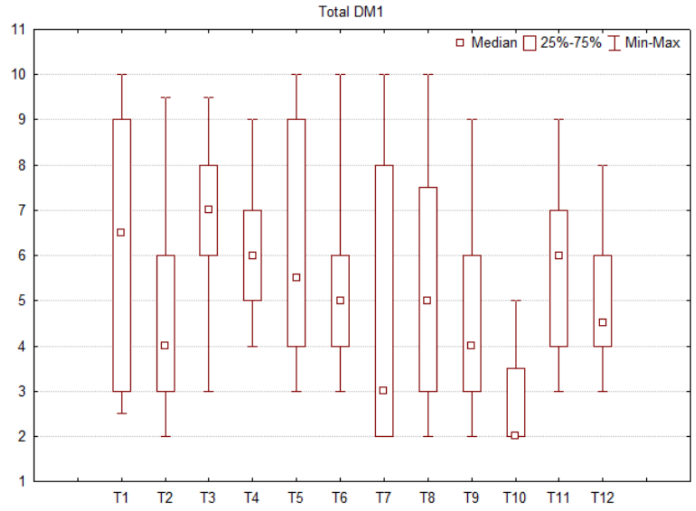

Figure 3: Box plot – final evaluation of thematic units for DM1

As its obvious from Figure 3, thematic units T1, T3, T4 and T11 reached the highest weight ratio. Pay your attention on median value, which is for these thematic units one degree higher than median values for other thematic units. For thematic units T1, T5, T7 and T8 was the weight ratio diversity the highest. As by first so by second cycle of subject Discrete Mathemathics 1, thematic unit T10 reach the lowest weight ratio. Median value for this thematic unit is 2. For thematic units T3, T4, T6 and T10 teacher answers were most intergrated.

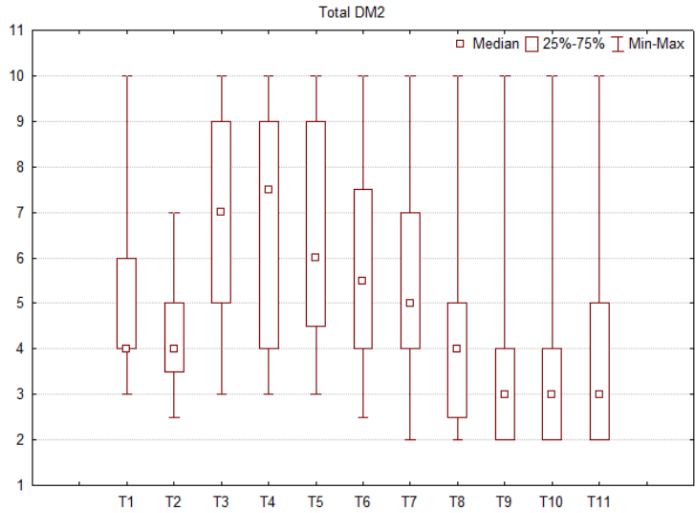

Figure 4: Box plot – final evaluation of thematic units for DM2

As its obvious from Figure 4, thematic units T3 and T4 reached the highest weight ratio. Pay your attention on median value, which is for these thematic units one degree higher than median values for other thematic units. This group should include thematic unit T5 because of third highest median value. However, thematic unit T4 has the highest diversity of weight ratios.

Proposal of the structure and content of the e-course of the subject discrete math with the support of Web 2.0 technology

To sustain a good educational trend by using modern ICT forces us to look for to implement the newest methods and forms of teaching. At present, those seem to be AHS that present a higher form of e-learning. (Turčáni and Kapusta, 2008)

The proposal of the structure of the course draws from the knowledge, which was obtained from the questionnaires, in which pedagogues allotted weighted coefficients to individual thematic units. In the subject DM1 the most important thematic units were as follows: T3 (Relation of divisibility and its attributes), T4 (The least common divider, the least common multiple, Euclid ´s algorithm), T1 (Basis of prepositional calculus), T5 (Diophant´s equations).

In the subject DM2 the highest weighted coefficient was reached by the following units: T3 (Definition of the graph, the graph peak grade theorem, the theorem on the existence of the graph with the given grades of peaks, an algorithm for the finding out whether the given sequentiality is graphic), T4 (Continuity of the graph –sequence, route, trace, connection, course, the theorem on the number of sequences of the length between two peaks of the graph), T5 (Algorithm for the testing of graph continuity). Thematic units with the highest weighted coefficient show direct influence on further studies of students.

The input capital of inventions, themes and creativity, selection of the way and time of realization, lies within the pedagogue ´s authority himself/herself. This would require a creative, well prepared teacher with competences, skills and knowledge not only from the sphere of technical education, but also many other areas, last but not the least, educated or literate in the sphere of ICT (Burianová and Magdin, 2009).

The solution of courses itself will be realized in two ways, either by a branch or linear teaching software. Branch software is particularly favourable when the provision and manipulation with new concepts is in question. Its fundamental asset is that it allows the student learning the content of education for choosing his individual way along the line, which corresponds to his intellect and previous knowledge. The linear teaching software is characterized by the fact that the learning contents is presented in small sections, however, the best way is to present just a single section in each step. The units with the highest weighted coefficient follow the subjects of the technical - system nature. Among these subjects are Computer Architecture (AP), Operation Systems (OS), Computer Networks (PS). These subjects form a part of the study programme Applied Informati cs/Bc.

From the perspective of computer terminology, tactics are the individual steps (sub-processes of learning a student) that are observable, registrable and measurable. With the terminology used and its content, we will work in drawing up rules for assigning the appropriate parts of the study support to the different types of students.

Various teaching methods consist of meaningful sequence of learning steps. Learning process phasing into three basic parts can be found in many publications:

- Motivating - is intended to arouse the student interest in teaching content,
- Exposing - phase of the passing on the curric

- ulum content,
- Fixing - allows consolidating of students' gained knowledge, skills and habits (Kostolányová, Czeczotková and Šarmanová, 2010).

Linear teaching software

By means of these Petri nets we modelled the structure of future e-course for the subjects Discrete Math 1 and Discrete Math 2. Petri nets seem to be the most effective way of their simulation and realization.

The beginnings of model ling the user stretch to teaching systems. The aim of model ling the user is thus preserving the values connected with the user, which reflect the level of his knowledge and their employment upon adjusting the system (Turčáni, 2010). They prescribe for all students a fixed and definite sequence of steps along one line.The teaching contents is taught in small sections of information, however, the best way is to present just a single section in each step. At need, the created concept is practised until the student manages it. Adding one concept to the other the student gets acquainted with the whole subject - matter and its whole problem. Conciseness of steps does not allow for the expansion of the prosaic style of explanation, so linear software is monotonous and after a certain time it becomes less interesting and very tiring. From the beginning until the end stretches one straight line compound of rules, exercises and answers Figure 5. Opponents of a linear software state that very small steps interrupt the student´s trains of thought in an undesirable way. According to practical experience is linear programming suitable for the teaching of basis and principles of the problem, moreover, for the forming of the word -stock and new concepts (Klimeš, Balogh, 2010).

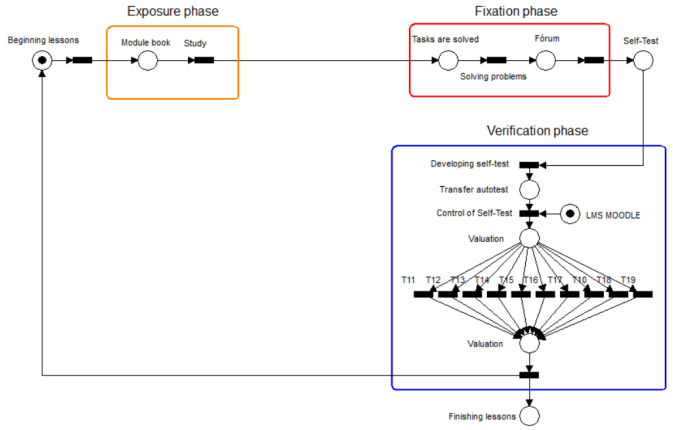

Figure 5: Linear model of the student´s transition in the lesson

Branch teaching software

When solving the problems, they allow for various procedures. Alternatives of „branches" of the programme finally lead to the successful joint coping with the problem. Every student, however, passes the way defined in advance, while the length corresponds to his personality, knowledge and capability. When teaching facts the programme has a clear main line, from which side lines shaped in different ways evert and then connect again Figure 6.

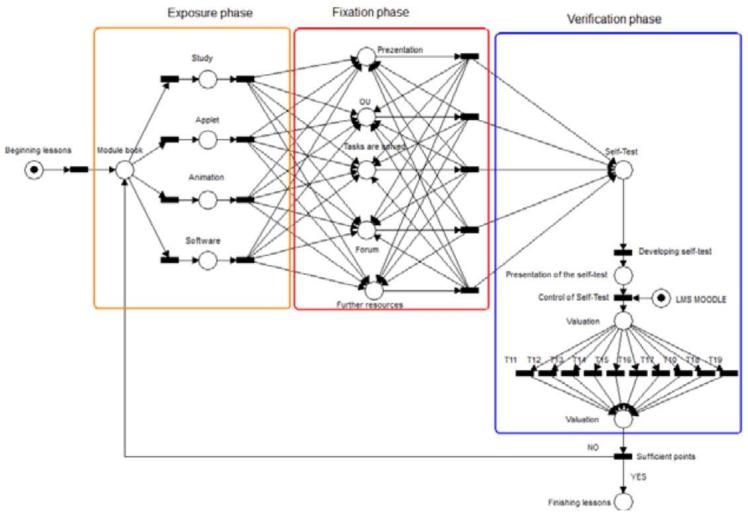

Figure 6: Branch model of the student´s transition through the lesson

The main line usually permits the procedure in larger and more demanding steps, which can be coped with only by a gifted student, correctly answering the inserted check questions; shorter and easier steps for less endowed students, or those working more slowly, are typical for side branches. Exercises for a successful practising of the given subject - matter, tasks, instructions and directives are inserted in them, facilitating the student´s solution of the problem, or using a visual aid or sequence, complementing the content of education in order to strengthen the opinion or fact. Larger information content of individual steps at the branch software admits its activation and for the student it is more interesting when presented in the form of a dialogue. Branch software is especially suitable in case when the provision and manipulation with new concepts are concerned. Its basic contribution is that it allows the student for choosing an individual way in acquiring the content of education along the line, which corresponds to his intellect and previous knowledge. Each of these basic types of software has two further variant s according to the fact that whether the student forms the check questions, or chooses them out of the offered variants of answers (Klimeš, Balogh, 2010).

Modelling the student´s transition through the course using Petri nets

The student´s transition within the whole course is simulated using a linear Petri net Figure 7. According to the current position of the token in the model Petri net we can find out in which section of the course the student is momentary situated, or to which lesson or setting he is addicted himself. The situation in reality need not be so simple. Settings, which should be elaborated by the student, will be submitted for inspection and subsequent evaluation to the pedagogue, who will assign the assessment. If the student does not reach the required number of points, he is allowed to make a correction to the setting. We expect that during the semester the student studied materials and continuously elaborated settings in all ten lessons over all the defined points in the Petri nets. We suppose that this procedure of the student was linear. The locations (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10) represent individual lessons, through which the student passes, and points (P1, P2, P3, P4, P5, P6, P7, P8, P9, P10) are the check settings (self - tests) for the verification whether the student understood the given lesson.

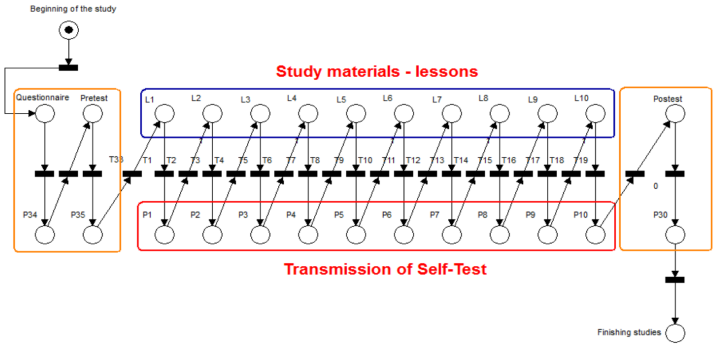

Figure 7: Transition of the student within the course using the linear Petri net

The hand - over of settings takes place as follows:

- Study of materials
- Solution of setting
- Hand -over of setting
- Assessment by pedagogue
- Allotment of the number of points, or correction of setting and the following adjustment of the number of points.

If the student does not reach the required number of points, she/he will have to repeat the given lesson. If she/he reads the lesson through, she/he will be allowed to pass the check setting again. The final function of the learning management system (LMS) is routing the communication depending on the student's knowledge and abilities and according to that changing the quantity and ambitiousness of the material offered to the student. Interaction between student and LMS in the process of teaching and learning is a composite process. The aim of the system for the teaching control is to regulate the communication according to the student's knowledge and ability and thus modify the amount and sophistication of submitted materials for the student. (Balogh, Koprda, 2012)

Discusion

To process thematic units we used linear and branched educational programmes. Linear educational programm was used by thematic units with lower weight ratio. This means that for the subject Discrete Mathematics 1 we are talking about thematic units T2, T5, T6, T7, T8, T9, T10 and T12. For the subject Discrete Mathematics 2 we are talking about thematic units T1, T2, T6, T7, T8, T9, T10 and T11. Branched educational programme was used for thematic units with the highest weight ratio. We found out that the most important thematic units from the subject DM1 are T1 (Basic of propositional count), T3 (Relation of divisibility and its attributes), T4 (least common divider, least common multiple, Euclides algorithm), T11 (Hamilton figures). From the subject DM2 we are talking about thematic units T3 (Figure definition, theorem about figure top degrees, theorem about figure existence with given top degrees, algorithm to find out if given sequence is figureable), T4 (Figure continuity – sequence, pull, route, connection, line, theorem about sequence length number k between two tops of figure), T5 (Algorithm to test figure relationships). Thematic units with the highest weight ratio have straight impact on further study. Thematic units with the highest weight ratio are followed by technical - system subjects. Within these are Computer Architecture (CA), Operational systems (OS), Computer nets (CN). All of them are compulsory subjects of study programme Applied Informatics/ Bc.

Conclusion

Authors in their contribution attempted at describing the proposed structure of e-learning course in the subjects Discrete Math 1 and 2 in details. They expected that in this manner adjusted materials will have a direct impact on the knowledge of students. The knowledge could become long-lasting, which will cause an increase in their expertness upon their further studies.

For the detection accuracy and efficiency of our proposed methodology was used to experiment, in which students would be divided into two groups: control and experimental. The control group undergoing conventional teaching method and the experimental group would enjoy learning with our suggested model wi th the implemented e-course in the Moodle LMS. Research sample was composed by first year students what represent age group 19-38 years. The whole research sample composed 107 students with 91 men (85,05%) and 16 women (14,95%). From this 107 students the control group was composed by 72 students with 59 men (81,94%) and 13 women (18,06%). Then the experimental research sample was composed by 35 students with 32 men (91,43%) and 3 women (8,57%). The evaluation of learning outputs is a complex process. The efficiency measurement of individual teaching methods is very difficult, because there are many factors, which influence such efficiency together; it is practically impossible to extract the impact of one specific factor and analyze it separately (Houška, Houšková Beránková, 2011).

Both groups have taken control test from Discrete Mathematics before using e-courses. After finishing semester students completed final test. Both groups results were compared and statistically processed using mentioned methods. Expected result should reflect in higher knowledge of Discrete Mathematics and also by obtaining knowledge from technical informatical subjects like: Computer Architecture, Operational systems, Computers nets, Computer Graphics and other areas of teaching Informatics field of study for students of KI FPV UKF in Nitra.

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THE EFFECT OF INTELLECTUAL CAPITAL ON KNOWLEDGE MANAGEMENT: STUDY ON AGRICULTURE ORGANIZATION EXPERTS IN KURDISTAN PROVINCE

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Abstract

This study aimed at exploring the effect of intellectual capital (IC) on knowledge management (KM) among Agriculture Organization experts of Kurdistan Province. Statistical population of this study consisted of all Agriculture organization experts in the Kurdistan province of Iran (N=326). Using Cochran's sampling formula, 63 farmers were selected as a sample. Respondents were selected by using Stratified random sampling method. For increasing reliability of the findings, 125 questionnaires distributed among experts, ultimately 101 questionnaires completed and analyzed in SPSS software. The instrument of the study was a questionnaire which its validity was confirmed by a panel of experts and its reliability was established by calculating Chronbach's Alpha Coefficient (α>0.7). Data analysis was performed by SPSSwin18 software.

The Results of this study showed that level of IC and KN was moderate among Agriculture organization expert. Moreover, Results of correlation analysis showed that there is a significant positive relationship between indicators of the IC (human, structural and relational) and KM. Finally, the results of stepwise multiple regression analysis showed that the indicators of IC (human, structural and relational), they can to explain 4.6% of the variance in the dependent variable.

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Knowledge management, intellectual capital, knowledge creation, innovation, Kurdistan

Introduction

Knowledge has become a powerful tool for corporate competition (Shih et al., 2010), and successful companies do not gain benefits with only tangible assets, and they mainly rely on access to intangible information and knowledge creation as their major resources for success (Guthrie, 2001). Enormous economic and business theorists express that knowledge is the only resource that is difficult or even impossible to duplicate or copy. So it has a good knowledge of the country itself, is unique. Obviously, such a resource must be protected, rehabilitated and managed and any technique is used that provides it better growth and spread (Adli, 2005).

So in this conditions knowledge application refers to that knowledge that has been shared by members of a firm is utilized in innovation (Yli-Renko et al., 2001). Through utilizing the diversified tacit knowledge grasped by organizational members, knowledge application enables firms to respond timely to the technological changes by applying the knowledge generated into products or processes to innovative activities (Song et al., 2005 & Li, Yuan, 2009). Hence Li, Yuan (2009), provides a similar definition of organizational knowledge and also he says that the human element is as the most important element in creating and applying knowledge in organizations. Furthermore, insists that the knowledge is formed and used through of circulation between interaction and individuals in an organization and communication between them. The profile of KM is one of the fundamental ways of guarantying competitive benefits in the global marketplace, has flourished in the recent period of time (Davenport and Prusak, 1998; Drucker, 1988; Lesser and Prusak, 2002; Nonaka and Takeuchi, 1995; Scarbrough et al., 1999). Generally, KM is all about methodically developing, preserving, and making access possible to an enormous stock of knowledge that subsists within organization (Prusak, 2001; Roos and von Krogh, 1996). Several studies have been done on knowledge management in the world, But since, this study has conducted for Agriculture Organization (as a government agency) hence more attention to the studies has been in this field. For example, a study conducted about of knowledge management in government agencies, was considered Relationship between organizational components (organizational culture, organizational structure, technology, human resources and political orientation) and the ability of knowledge creation and knowledge transfer in the Ministry of Entrepreneur Development of Malaysia. The Results show that there are a significant correlation between these variables and the ability to generate and transfer knowledge (Skyreme, 1998).

Organizations employing knowledge management strategies they have provided to innovation in processes, activities, products and services. So, recognition of factors affecting enterprise knowledge management is one of the initial actions in the effective use of the organization's intellectual resources. Training organizations have knowledge within their inside and after processing the information into knowledge according to routine method, incorporation of knowledge with values, strategies and experiences will be basis of decision-making and future actions of organization (Bahrami & et al., 2011).

Davenport and Prusak (1998) note that technological advances in data processing, communication, and transportation, as well as employed demand and strategists' planning have made the world economy change very fast. It has been the biggest wave of changes since the Industrial Revolution. The economy is dubbed 'knowledge economy', as the prime commodities are knowledge and information (IC). Knowledge creates and leverages the intangible value of companies that is IC. Teese

(2000) notes that with the growth of the knowledge-economy, the intangible assets of the firm and its IC are the keys to achieving sustainable competitive advantage. Hence in the new economy, intellectual capital has been described as intangible assets as well (shojai & et al, 2009). Intellectual capital is defined as intangible assets which include technology, employed information, brand name, reputation and corporate culture that are invaluable to a firm's competitive power (Low and Kalafut, 2002),). Hence, IC consists of (1) tacit knowledge and innovativeness of the employees, (2) infrastructure of human capital (i.e. good working system, innovation) and improvement processes of structural capital and; (3) external relationships of the firm (i.e. employeds' capital). These are the key drivers of organization performance and creation of future wealth. (Bontis et al., 2000; Riahi-Belkaoui, 2003). In realizing the goals of a progressive and dynamic financial sector and the desire to become a knowledge-based economy, greater efforts must be directed to building human intellectual capital (Lepak and Snell, 1999). Furthermore, intellectual capital can be viewed as a mix of human capital, structural capital and employed capital (Bontis, et al; 2000, Riahi-Belkaoui, 2003). Figure 1 illustrates this:

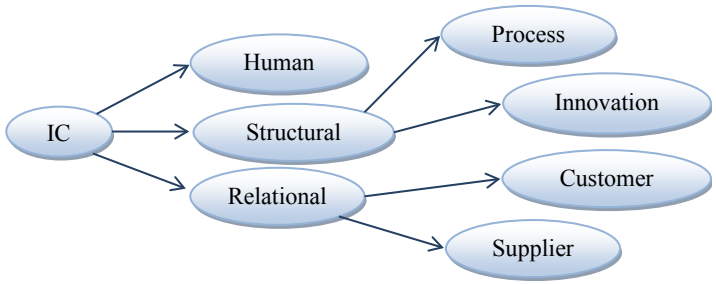

Figure 1: division of IC

Human capital generates innovation – whether of new products and services or improving business processes. Structural capital is the knowledge that belongs to the organization as a whole in terms of technologies, inventions, data, publications, strategy and culture, structures and systems, organizational routines and procedures. Finally, employed capital is the firm's value of its franchise, its ongoing relationships with the people or organizations to which it sells, like market share, employed retention and defection rates, and per employed profitability. Only structural capital, which is owned by the firm, and is assumed not to be reproduced and shared, is the best approximation of intellectual capital. Stewart (1997) indicated that IC refers to the aggregation of all knowledge and competences of employees that can bring about competitive advantages for companies. Any intellectual materials that can create wealth, such as knowledge, information, techniques, intellectual properties, experience, learning ability of organizations, and employed relationships, can be the most valuable assets and most advantageous tools in competition.

Most previous KM literatures addressing IC have focused on the correlation between IC and organizational performances (Chong and Lin, 2008; Ho, 2009). There are relatively few discussions on the relationship between knowledge management and IC, and even fewer studies on such a relationship in the agriculture organization. The core competitiveness of the banking industry is highly reliant on the ability of management teams to systematically manage knowledge and experience. It also depends on whether they are able to create sophisticated skills catering to the IC of their organization to effectively manage risks and create profits. The accumulation of IC and knowledge creation is closely related (Rezgui, 2007; Lin,et al., 2008). IC is generated via systematic integration of knowledge (Shih et

al., 2010). Alo, The study conducted by Kurdabady Salehi & et al(2010), that has done to Explain the relationship between intellectual capital and knowledge creation as the insurance company. The survey results indicate that there is significant relationship between intellectual capital and knowledge creation. In addition, Shih & et al (2010) showed that the performance of knowledge creation has significant influence on the accumulation of subsequent human capital. Cognitivists and connectivists are considered the main knowledge creators in the banking industry. The performance of human capital exhibits significant influence on structural. Capital and employed capital. The performance of employed capital reports significant influence on the formation of structural capital.

At present now, Iran is as a country rich in natural resources, abundant capital and labor activist is desirable. so, needs to group of skilled, experienced, active, educated and professional in all fields such; economic, social and cultural. Therefore, the directors which they are aware and competent are necessary for coordinate human and material resources that they facilitate to achieve economic, social and cultural rights in the country. Therefore, to achieve success in a complex and uncertain situations and in situations where time is constraints, KM, learning and development in organizations is presented as a solution. In this regard, IC is as one of the most valuable resources that can be considered as an asset in the organization. Based on this study, investigate the effects of IC on KM in the agricultural organization experts of Kurdistan province; to achieving the goals will be pursued the following specific:

1. Evaluation of personal and professional characteristics of experts
2. Assessing IC and KM sample Experts
3. Investigate the relationship between Aspects of IC and KM
4. The effectiveness of each of the dimensions of IC on KM

Materials and methods

The design of the study was a descriptive survey that done by single cross-sectional study. Statistical population of this study consisted of all Agriculture Organization experts in the Kurdistan province of Iran (N=326). Using Cochran's sampling formula, 63 farmers were selected as a sample. Respondents were selected by using Stratified random sampling method. For increasing reliability of the findings, 125 questionnaires distributed among experts, ultimately 101 questionnaires completed and analyzed in SPSS software. The instrument of the study was a questionnaire which its validity was confirmed by a panel of experts and its reliability was established by calculating Chronbach's Alpha Coefficient (α>0.7).

The questionnaire consisted three parts that include: 1. personal, social, and economical characteristics and 2. A scale was used to measure intellectual capital. Of course in this section was used of the intellectual capital model Betis (2001) then prepared 18 questions in five-degree Liker range (1 - totally disagree to 5 - completely agree). That is measured three indicators from intellectual capital: structural capital, relational capital and human capital. 3. In this section the questionnaire used of Knowledge Management models Lawson (2003), and Based on prepared of 30 questions in five-degree Liker range (1 - totally disagree to 5 - completely agree). That is measured 6 indicators

from KM: Organizational knowledge, knowledge application, knowledge storage, knowledge creation, knowledge capture and dissemination of knowledge.

In order to, estimate the reliability of the questionnaire Cronbach's alpha coefficient was established. For each part of the questionnaire Cronbach's alpha coefficients was over 0.7. Thus, the reliability of the questionnaire was excellent for research. Data analysis was performed by $SPSS_{win18}$ software. Thus, in the part of descriptive statistics were used of: frequency, percentage, mean and standard deviation and in the inferential statistics used of correlation coefficient and multiple regressions.

Results and discussion

-Personal and professional characteristics of experts:

The results of the study showed that the average age of experts was 31.12 years old and SD was 7.43. Which the youngest of them have at 23 years old and the oldest was 59 years. The average farming experience was 11.4 years and a SD 7.23 respectively. Based on the findings of the among survey population 69 percent were educated in agricultural fields and 31 percent in non-agricultural fields.

- Assessment of intellectual capital and knowledge management among experts:

In order to evaluating the level of intellectual capital and its indicators and also, to prioritize the indicators of intellectual capital among experts was used from the mean and coefficient of variation. The results of this section are showed in table 1.

Indicators	Mean	SD	CV	rank
- structure Capital	4.44	.721	16.2	1
- Relational capital	3.98	.698	17.5	2
- Human capital	4.25	.753	17.7	3
- Intellectual capital	4.02	.705	17.5	-

* Scale: 1-Strongly Disagree to 5-Strongly agree

Table 1: Ranking of intellectual capital indicators among experts

According to findings on table 1 results shown that the level of intellectual capital and its constituent indicators among experts is more than average. Therefore, we can say that the Agriculture Organization experts they have favorable in an intellectual capital. Also, the results in Table 1 indicate that Structural capital indicator is located from higher priority than other indicators of intellectual capital.

In order to evaluation the level of Knowledge management and its indicators and prioritize km indicators among sample experts C.V. statistical method was used. The results are given in Table 2.

Indicators	Mean	SD	CV	rank
Knowledge creation	4.01	.688	17.1	1
Organize knowledge	4.03	.701	17.3	2
Power of knowledge	4.47	.780	17.4	3
Knowledge dissemination	3.95	.745	18.8	4
Storage knowledge	3.85	.752	19.5	5
Application of Knowledge	3.52	.695	19.7	6
KM	3.87	.706	18.2	-

* Scale: 1-Strongly Disagree to 5-Strongly agree

Table 2- prioritize indicators of KM among agriculture organization experts

In the table 2 results shown that the mean of Knowledge management level and its indicators among sample experts are higher than average. Therefore, we can say that the Agriculture Organization experts relatively are good from level of knowledge management. In addition, the results of table 2 shown that the among indicators of forming a knowledge management: Indicators of knowledge creation and knowledge organized respectively are higher priority than other indicators of constructive knowledge and also indicator of knowledge application and knowledge of storage, respectively are lower priority than other indicators of constructive knowledge among agriculture organization experts.

-Examine the relationship between dimensions of intellectual capital and knowledge management

In order to examine the relationship between intellectual capital indicators and knowledge management, among Agricultural Organization experts was used of the Pearson correlation coefficient. The results are shown in Table 3.

	KM	
Dimensions	Sig	r
- Structure Capital	0.000	.540**
- Relations capital	0.000	.467**
- Human capital	0.000	0.463**

**Significance at P<0.01

Table 3 - examine the relationship between IC indicators and knowledge management

Based on the findings presented in Table 3, Correlation analysis showed a significant positive relationship the level of 1% between each of the indicators of intellectual capital and knowledge management.

- Determining the effect of each of the dimensions of IC on KM

In order to determination the effect of each of the dimensions of intellectual capital on knowledge management used of Stepwise multiple regressions. The stepwise method of regression analysis is the method in which the most powerful variables enter into the regression analysis and equation and this continues until the error of significance test reaches 5 percent (Kalantari, 2010). Then, in this study the dimensions of intellectual capital (human, structural, relational) as independent variables and KM as the dependent variable were entered into regression analysis. The results are shown in tables (4, 5 and 6).

Statistical indicators	R	R^2	Adjusted coefficient
The coefficient	.752	.624	.502

Table 4 - Multiple correlation coefficients on the effective of IC with KM respondents

Based on the findings presented in Table 4, the multiple correlation coefficients (R) were equal to 0.752 that Indicating the high correlation between the dimensions of IC and KM among respondents. Also determination coefficient (R^2) was equal to 0.624. In other words, 62.4% of the variability dependent variable (knowledge management) was explained by dependent variable (the dimensions of intellectual capital).

Changes in resources	Sum of squares	Degrees of freedom	Mean square	F	Sig
Regression	4588.352	4	1556.852	15.321	0.000
Remaining	19852.852	165	127.658		
Total	23548.635	185			

Table 5 - Estimated regression model using the F (variance analysis)

In the table 9 results showed that multiple regression models combination of IC (human, structural and relational) can explain the variance related to km, so that the amount obtained F equal to 15.321that is significant at 1% level. Also, result in table 5, represents a significant regression and linear relationship between variables research.

Variables	B	Std. Error	β	t	Sig
Constant Coefficient	58.125	5.569	-	12.324**	0.000
- structure Capital	.897	.157	.457	3.985**	0.000
- relations capital	1.457	.241	.201	3.562**	0.000
- Human capital	.586	.254	.119	3.002**	0.000

Table 6 - The impact of Intellectual capital on KM respondents

Given the above results of Table 6, the linear regression equation is shown as follows:

$$Y= 58.125+ 0.897_{x1}+ 1.457_{x2}+ 0.586_{x3}$$

That in this equation:

Y: knowledge management

X_1: structure Capital

X_2: relation capital

X_3: human capital

Based on results in table 6, Can be seen that the t values of individual regression coefficients are significant at 1% level. This reflects the strong influence of intellectual capital in knowledge management responds.

Significant results of F and T tests indicate the regression model is valid. But the regression equation does not say anything about the relative importance of independent variables. To determine the relative importance of independent variables, Standardized coefficient (β) should be considered. This statistics shows the effect of each independent variable separately from the effects of other variables on the dependent variable. Accordingly, the most influential independent variable for the predicting dependent variable, was the variable human capital with β=0.457 toward other dependent variable (knowledge management). This means that unit changes of standard deviation of the human capital explain 0.457 of unit change in standard deviation of the dependent variable. Based on, other important variables influenced the dependent variable were: relations capital with β=0.201 and structure capital β= 0.119.

Conclusion

Based on the results of the literature, knowledge is as the main source for innovation and organizational productivity. Application of knowledge management will lead to innovation in Organizations. Hence, that knowledge management is often known as a main source of Innovation and also is considered the necessity of innovation in organizations. Furthermore, Intellectual capital is as one of the important organizational capabilities that they can help organizations to creates knowledge and its management and also sustainable competitive to other

Organizations. Intellectual capital could be affected in knowledge management, employees. Therefore, this study

aimed at exploring the effect of intellectual capital on knowledge management among Agriculture Organization experts of Kurdistan Province. As well as the correlation between human capital, structural capital, and customer capital, as the three types of IC. That found the following results:

Based on the results between each of the indicators of intellectual capital and knowledge management; Correlation analysis showed a significant positive relationship the level of 1% between each of the indicators of intellectual capital and knowledge management.

Based on the results of correlation analysis; that there are high correlation between the dimensions of intellectual capital and knowledge management among respondents. Correlation analysis can be described that the intellectual capital of individuals is higher than the level of their knowledge is higher.

In addition, multiple regression results showed that the Dimensions of intellectual capital capable of to explain 62.4% of the variance in the dependent variable (km).

Finally, the results showed that the development of intellectual capital in organizations of Agriculture surveyed is effect on the development of knowledge management. And also, intellectual capital in the organization and effective interaction among the organizations can provide to facilitate knowledge management in organizations. Moreover, ability to develop creativity and innovation in the organization increases.

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EDUCATIVE EFFECTS OF SPATIAL VISUALISATION

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Abstract

The article deals with the issue of the impact of spatial visualization on education. It reports on some of the findings of a research project focused on defining the correlation between components of spatial intelligence and absorbing the information presented by planar or spatial visualization. The research examined educational impact of differences in mental models of lower-secondary school students watching spatial visualization in relation to mental models formed through watching planar visualization and also a level of cognitive strain of learners perceiving spatial and planar visualization in relation to their specific predispositions, namely to various components of spatial intelligence.

Key Words

Education, planar visualization, spatial visualization, mental model, spatial intelligence

Introduction

The premise of this paper on spatial visualization and its application in education is the presumption of the high educative potential of spatial visualization technology as a technical instructional tool and the expectation of spreading the technology into the school environment and into the educational sphere in general. However, spatial visualization as a scientific concept is not fully acknowledged. At the same time, spatial visualization has recently experienced accelerated development as well as diversification from the perspective of technological solutions and applications. In addition to classic technologies based predominantly on binocular parallax, there are emerging technologies based on holography, and even technologies based on direct spatial visualization or light field reproduction. Widely used technologies using monocular depth perception cues such as interposition, linear perspective or motion parallax cannot be seen as truly spatial.

These technologies are often marked as 3D. But the term 3D cannot be simply seen as a synonym for spatial visualization. This term (i.e. three-dimensional) simply means that the technology takes into account three dimensions, therefore making it 3D. The three dimensions do not necessarily convey the ability to express the location in space, therefore it does not necessarily mean spatial. E.g. when a computer game claims to be 3 dimensional, it is far from being spatial when viewed on a standard LCD display. Since the spatial depth is supported by monocular hints, these technologies are often marked as 2.5D and they represent the so called pseudo spatial visualization (Oh et al., 2011).

It can be assumed that truly spatial visualization would only be such a visualization that evokes binocular disparity, which together with motion parallax maximizes the perception of depth (Sekuler and Blake, 2005, p. 221).

In an attempt to more precisely classify the incorporation of spatial visualization means into the system, both technological and perceptual views should be taken into account. The perceptual characteristics should be considered as some of the most important aspects of the evaluation of spatial visualization means as it describes the substantial attributes of spatial visualization from the perspective of the viewer's perception no matter what the visualized model is. The perceptual characteristics are usually derived from the technological origin of the visualization and they are hence usually unchangeable for the given technology, or the possibility of change is quite limited.

From the technological perspective, spatial visualization means may be divided into four dominant bases: the technologies that are parallactic, direct spatial visualization technologies, light field systems and holographic technology.

From the perception perspective, spatial visualization means can be divided by using three perceptual axes. The first axis shows the number of subjects that can view the visualization. As for the number of viewers, there are two main possibilities of observation of spatial visualization, monoscopic (set for one viewer) or polyscopic (set for more viewers). If there are more viewers experiencing the spatial visualization at the same time, the perception is highly influenced by the ability of the visualization to mediate the active motive parallax.

The second axis shows the ability of the visualization to adjust to the change of physical location of the viewer in relation to the visualization by inducing the motion parallax. The motion

parallax is, beside the binocular disparity, the second strongest cue in depth-perception (Schiller, Slocum, Jao and Weiner, 2011). This is very important for bringing the visualization closer to the real experience. We may also distinguish technologies supporting only passive parallax and active parallax (parallax emerging by changing the location of the viewer while the viewer perceives the change of the view point towards the model).

The third axis shows the form of visualization and reflects the subjective perception of visualization. The form can be convex, planar or concave. From the subjective perception of the scale of visualization, there are two extremes of this perceptual axis, total convex and total concave visualization. In total convex visualization, the viewer could observe the model in a "crystal ball" from any horizontal or vertical angle. In total concave visualization, the viewer could look in any vertical or horizontal direction, i.e. he would be "inside" the ball.

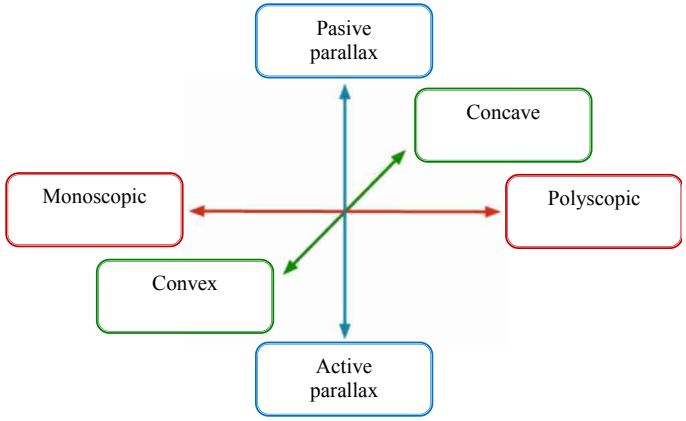

Figure 1: Axes of perceptual characteristics of spatial visualization

Classification of individual means of spatial visualisation can be based on the above mentioned perceptual characteristics, identifiable across the technologies regardless of the design and the principle of the device. It can be assumed that even technologies likely to emerge in the near future will have the same perceptual characteristics based on the perceptual aspects and will fall into the existing perceptual categories. Table 1 shows the technologies (or specific members of significant technological groups) as classified into perceptual categories.

	Parallactic								Direct volume				LF		Hologram		
	Anaglyf	Chromadepth	Stereoscope	Autostereogram	HMD	CAVE	Stereoprojection	Autostereoscopic d.	PDVD	Perspecta	DepthCube	SolidFelix 3D	LF360	HoloVizio	Hologram	Digital hol. print	Holgraphic display
Number of subjects																	
Monoscopic	+	+	+	+	+	+	+	+	-	-	+	-	-	+	+	+	+
Polyscopic	+	-	-	-	-	-	+	-	+	+	-	+	+	+	+	+	+
Form																	
Convex	-	-	-	-	-	-	-	+	+	+	+	+	+	-	-	-	-
Planar	+	+	+	+	-	-	+	-	-	-	-	-	-	+	+	+	+
Concave	-	-	-	-	+	+	+	-	-	-	-	-	-	+	-	-	-
Parallax																	
Passive	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Active	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+

Table 1: Perceptual characteristics of spatial visualisation means (LF = Light Field, HMD = Head Mounted Display, CAVE = Cave Automatic Virtual Environment, LF360 = Interactive 360º Light Field Display) (allows for= '+', does not allow for = '-')

Depending on the kind of applied technologies and the pertinent application area, there is a wide range of various tools of spatial visualization for the visualization of both particular real world objects, as well as various virtual objects, complex virtual worlds or notion or data structures. Spatial visualization is also gradually finding its way into the area of education, so far primarily as an experiment, and presumably it may soon replace some teaching aids, or overcome them and thereby significantly contribute to a higher quality of education. It may be assumed that spatial visualization has certain perception and didactical specifics that influence the quality of the process of receiving educational contents, its processing and induced cognitive processes, and above all the processes of mental representation and creating mental models in relations to spatial intelligence of the perceiving subject (Sternberg, 2002).

The above mentioned premises have become the authors' focus as part of the research into spatial visualization, concentrating on characteristics, specifics, and the role and position of spatial visualization in education.

The field of spatial visualization is rather unclearly defined and its notion, from the perspective of education science, is characterized by certain conceptual and terminological inconsistency. The research on the usage of spatial visualization in education is usually focused on particular aspects which do not represent the topic in its whole complexity. Mainly, there are surveys on spatial imagination (Górska, 2005) and its development, or the correlation between spatial imagination and successfully learning certain subjects (Sorby, 2007). Some sources (Mikropoulos and Natsis, 2011) also show that the manner, by which mental representation of perceived reality is constructed, above all mental models, differ significantly in comparable groups of individuals, depending on whether planar or spatial models are used during the processes of creating such models representing the given object. Furthermore, there are surveys comparing the results of instruction, using either common or spatial visualization (Esparrachiari, 2005) and surveys on virtual reality or virtual learning environment (Dalgarno and Lee, 2010).

The survey on spatial visualization and its application in education that this article is based on, intends to contribute to solving this issue from technology, cognitive psychology, and methodology viewpoints.An important part of the research was an empirical inquiry bound to the above mentioned goal.

The concept of didactic specifics is an important aspect. It is generally defined by a combination of specific qualities and abilities, or specific technological, organisational, didacticly-functional and other, from a didactic point of view, relevant parameters of the material didactic means, distinguishing it from other means from a viewpoint of achieving educational goals.

In general, from a standpoint of visualisation specifics, we can emphasize especially the presentation of content, interpretation and control information relating to education, or subject matter in the most suitable manner taking into account the goal or conditions.

Didactic specifics of spatial visualization are primarily based on the fact that this way of presenting educational data features, unlike any other standard way of projected visualisation, another dimension and thus enables to provide directly information that would otherwise have to be modified. Spatial visualization in comparison to planar visualisation shows broader potential of visual communication based mainly on using binocular disparity and direct visualization of depth in the visualized content. This principal advantage may in a suitable situation contribute to a

higher didactic efficiency. Spatial visualization, especially when immersive, can influence not only knowledge but also viewers' behaviour - a number of surveys prove that there are changes in mental models of behaviour as a consequence of playing video games. The influence of immersive environment in video games reinforces forming certain mental models more intensely than for instance watching television (Tamborski and Skalski, 2006).

Monoscopic systems of spatial visualisation primarily allow for a high level of individualisation and personalisation. They are suitable mainly for individualised educative forms with content and time differentiation in the lessons, although it is usually possible to use them in frontal teaching.

Polyscopic technologies of spatial visualisation enable more viewers to watch a visualised model at the same time and that determines them to be used in frontal teaching or group teaching.

The main didactic specific of the systems with active parallax is the possibility to explore a model through active motion of a viewer. A model visualised in this way is perceived by a viewer similarly to a real object and its effect on a viewer resembles real experience. Visual perception is less at odds with other position sensors.

From a didactic specifics point of view a determining factor of convex visualisation is the said fact that a viewer primarily perceives reality, does not lose continuity and spatial visualisation is only a part of his/her perceptual field. Didactic specific of concave visualization is the fact that viewers become a part of watched virtual world, which surrounds them.

Although it can be said that all means of spatial visualisation are to some extent interchangeable the adequacy of their application in didactic situations is determined, in addition to their didactic specifics, by visualised content (or visualised model) and parameters of the visualisation.

Attributes of visualisation of a model are defined, in addition to didactic purpose, by visual capabilities of chosen means of spatial visualisation, i.e. capabilities of the used technology limit the application of a specific model in teaching and possible parameters of its visualisation.

Complex character of a model relates to the graphical rendition of the template or complexity of a visualised model from the perspective of using simple graphical elements. Abstraction of a model represents the extent to which the visualisation is close to reality. Dynamism of a model enables to represent phenomena and actions in motion and progress, to capture causal links, changes in time and other time-dependent events. Colour can be used to differentiate certain parts of a model, highlight details, point out connections between various parts of a model, express characteristics of a model in certain part thereof (e.g. temperature) etc. Immersion usually means the extent to which spectators are captivated by virtual reality (Dalgarno and Lee, 2010). The more senses are stimulated by the virtual reality the more intense this stimulation is. Defining parameter of immersive visualisation is evoking the feeling of being inside the visualisation (presence, subjective presence, telepresence). The ideal means of spatial visualisation for presenting immersive models are concave, viewer-surrounding visualizations.

	Parallactic								Direct volume				LF		Holograph.		
	Anaglyf	Chromadepth	Stereoscope	Autostereogram	HMD	CAVE	Stereoprojection	Autostereoscopic d.	PDVD	Perspecta	DepthCube	SolidFelix 3D	LF360	HoloVizio	Hologram	Digital hol. print	Holographic display
Complexicity																	
Line graphics	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Graphics	o	o	+	o	+	+	+	+	-	+	+	+	+	+	+	+	+
Photographics	-	-	+	-	o	o	+	+	-	-	-	-	+	+	+	+	+
Abstraction																	
Symbolic	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Schematic	+	o	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+
Realistic	o	-	+	-	o	o	+	+	-	+	-	-	+	+	+	+	o
Dynamics																	
Static	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Animation	+	+	-	-	+	+	+	+	o	+	+	+	+	+	-	o	o
Dymanic	o	o	-	-	+	+	+	+	-	+	+	-	+	+	-	-	-
Color																	
Monochromatic	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Limited color	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+
Full color	-	-	+	-	+	+	+	+	-	+	+	+	+	+	o	+	+
Immersion																	
Immersive	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Non-immersive	+	+	+	+	o	o	+	+	+	+	+	+	+	+	+	+	+

Table 2: Characteristics of visualised model depending on used technology (LF = Light Field, HMD = Head Mounted Display, CAVE = Cave Automatic Virtual Environment, LF360 = Interactive 360º LF Display) (suitable = '+', partially suitable = 'o', unsuitable = '-')

Material and Methods

The inquiry was oriented on determining the impact of the application of spatial visualization in instruction on the results of learning as well as on spatial intelligence. The predisposition was that the level of spatial intelligence has a direct effect on the students' results or on their success at school. The assumption was also that the application of spatial visualization would lead to the improvement of students with a lower level of spatial intelligence, i.e. students that find it difficult to create an adequate mental model using planar visualization. The level of spatial intelligence was measured by a standardized test of mental rotations and the level of learning abilities by a didactical performance test. The hypothesis was that the students with a lower score on the test of mental rotations would perform better when spatial visualization is applied in the performance test than the students working with planar visualization.

The base method used in the research was the method of comparative experiment in educational settings. The experiment was organized in the form of pair selections at the given lower secondary (ISCED 2) school in 2011 and took place over two months. A group of 8th grade students (32 students, 20 boys and 12 girls) aged 14-15 were investigated. The students attended one class and during the experiment were divided into two comparable groups, wherein the instruction took place separately, but with the same teacher. The experiment was organized in three phases.

In the first (preparatory) phase the steps necessary for the creation of experimental group (E-Group) and control group (C-Group) took place. The creation of the experimental group was based on random selection from equivalent pairs of subjects to eliminate the differences and equalize the characteristics

of individuals in the groups. The evaluation criterion was the students' score in the mental rotations test MRT (SILC, 2008). The students were also presented with a spatial imagination Santa Barbara Solids Test SBST (SILC, 2008). School results in the last 2 years based on school reports were also evaluated. There were no gender differences in the results of tests MRT (A_M=13.1, A_F = 12.1) and SBST, nor in the learning results.

In the preparatory phase it was proven, as expected, that there is a positive correlation between the results in mathematics and the ability of mental rotations (cor = 0.69, p = 0.05).

The experiment took place within the teaching of mathematics. The topic taught during the experiment was solid geometry. During the experiment, both the experimental and control groups underwent 10 lessons (10 x 45 minutes). The lessons took place in the same classroom (one group followed by the other). The classroom was equipped with a whiteboard and an interactive board with a digital projector. The lessons were observed by the researcher and records were made of the process as well as incident notes. The records show that the structure of the lessons was in both cases identical. The only difference was the use of spatial visualization (anaglyph) in the experiment group. In the control group the perspective or isometric visualization was used instead. Spatial visualization methods were used for 170 minutes (38 percent of the whole time) during the teaching of the experiment group. No solid models were used.

During the instruction in experiment group the teacher was active for 176 minutes (39 % of total time). Pupils worked actively 327 minutes (73 % of total time). Both sides were active 102 minutes (23 % of total time). That means that pupils were passive only 74 minutes (16 % of total time). Administrative acts took 40 minutes (9 % of total time).

In addition whiteboard was used for 101 minutes (22 % of total time), interactive board for 131 minutes (22 % of total time) and digital projection for 30 minutes (7 % of total time). Spatial visualisation in instruction took form of anaglyphic projection for 170 minutes (38 % of total time).

		Control group		Experimental group	
		min	%	min	%
Teaching Aids	**Textbook**	9	19%	8	18%
	Workbook	3	6%	3	6%
	Exercise book	20	43%	21	47%
Equipment	**Whiteboard**	9	19%	10	22%
	Interactive board	9	19%	13	29%
	DVP	3	6%	3	7%
Spatial visualization	**Spatial visualization**	0	0%	17	38%

Table 3: The lesson structure in experimental and control group

During the instruction in control group the teacher was active for 173 minutes (38% of total time). The pupils worked actively 327 minutes (73% of total time). Both sides were active for 98 minutes (22% of total time). That means that pupils were passive only 75 minutes (17% of total time). Administrative acts took 33 minutes (7% of total time).

The bigger ratio of the use of interactive board in experimental group (29% experimental, 19% control) is the consequence of the use of spatial visualization that was presentable only by digital projection. The interactive features of the board were not used, or they were used in the same way in both control and experimental group.

During the experiment, the children had no problems such as headache, eye strain and other known problems when watching the anaglyphic visualization (Häkkinen, 2006).

Results

After the experiment the students of both groups, experimental and control, were given three performance tests (T1, T2, T3). Tests T1 and T3 were constructed out of common examples from everyday instruction. The test T2 was designed by the authors of the research emphasizing spatial imagination.

	AT1	RST1	NT1	AT2	RST2	NT2	AT3	RST3	NT3
E-HIMRT	11.8	69.0	8	17.3	63.0	8	11.4	69.5	8
C-HIMRT	12.8	67.0	8	18.3	73.0	8	11.1	66.5	8
E-LOMRT	6.8	87.0	8	11.0	84.0	8	12.4	95.0	8
C-LOMRT	3.5	49.0	8	8.4	52.0	8	3.9	41.0	8

Table 4: Final tests results (A = arithmetic mean, RS = rank sum, N = number of samples)

The students of both groups were divided into two sub groups. Subgroup HIMRT consisted of students that scored on MRT higher than average in the observed class. The subgroup LOMRT was made up of those scoring below average. The differences between the groups were tested on the basis of the Mann-Whitney U-Test.

In the given experiment, the students of the experimental group within subgroup LOMRT always scored better than the control group. In two cases the difference was statistically significant. On the T1 test at the level $p = 0.05$ and in the T3 test at $p = 0.01$. In the subgroup HIMRT the differences in the result of the experiment were statistically insignificant with the application of criteria at the level of $p = 0.05$. So it may be stated that spatial visualization has a positive influence on students with a lower level of mental rotations ability.

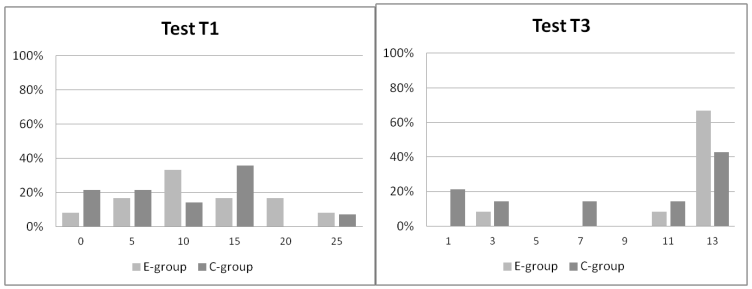

Figure 2: The relative number of results at the experimental and control groups

In the T2 test the scores of both groups, experimental and control, were similar ($p = 0.05$). This fact may be explained by the character of the assignments that were focused on the use of spatial intelligence not intentionally affected by the experiment. The results of both groups prove this assumption due to their equal composition.

Discussion

The empirical inquiry with its assumptions, process and main outcomes characterized in this article was focused on the research of the correlation between the form of the presentation of subject matter during instruction (planar and spatial visualization), ability of mental rotation of students, their school results, or school success. The researchers assumed that the level of spatial intelligence investigated by the test of mental rotations influences in relevant cases the results of learning and

particularly students with lower ability of mental rotations, the presentation of subject matter by spatial visualization would lead to better understanding and acceptance.

Since a low level of mental rotation ability correlates with study results in mathematics (Prokýšek and Rambousek, 2012), test 3 shows more accurately the pupils' results in LOMRT subgroup. In HIMRT subgroup, 7 out of 12 pupils (58%), who did the test, scored maximum points. From the viewpoint of T3 test, the pupils showed the same success rate.

Intervening variables, or their influence, in the experiment were eliminated to the maximum extent by the way they were carried out and the conditions of the experiment. The only variable which we can consider independent is the use or non-use of spatial visualization as a didactic means. The differences in the composition of experimental and control groups were eliminated by the pair selection method. The Hawthorne effect on the examined subjects is certainly not insignificant. The influence of the researcher on the subjects was eliminated by the presence of the researcher in both experimental and control groups. Besides, the researcher was in the classroom also before the start of the experiment itself. The length of the experiment contributed to the compensation of this effect as well. During this period, the used technologies and researcher's presence became commonplace for the subjects.

The results of the experiment cannot be generalized. It should be understood as a pilot project with qualities of a case study and with results valid only in the limited group. Nevertheless it was proven that the students of LOMRT, i.e. students with a lower ability of mental rotations, that used spatial visualization during instruction scored better in tests than their counterparts using planar visualization. So the tested hypotheses were proven. It was also proven that the students of the HIMRT group i.e. subset of subjects with a higher ability of mental rotations, were not affected by the spatial visualization in terms of test scores, not even in a negative way.

Conclusion

The project, which is dealt with in this article, sought to characterize the relation between the components of spatial intelligence and the process of absorbing information presented by planar and spatial visualization when forming mental models and to verify this relation empirically. The above stated results show that using spatial visualization in learning process, which requires pupils to use spatial intelligence, is effective mainly for the pupils with less developed spatial intelligence.

The ability of mental rotations may be understood as a part of spatial intelligence that has a direct link to the effectiveness of the application of visualization into the learning process. Within the application of planar visualization it supports the formation of the mental model and the manipulation of it. Within the application of spatial visualization the ability of mental rotations is involved in the process of creating a mental model to a much lesser degree. It also shows that spatial visualization supports the creation of adequate mental models during instruction that demands certain spatial intelligence. So the students with a lower level of spatial intelligence, or with a lower mental rotation ability, profit from spatial visualization more than those with a higher level of this quality.

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IS IT POSSIBLE TO ESTIMATE LABOUR PRODUCTIVITY IN THE CZECH HIGHER EDUCATION?

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Abstract

This paper deals with the issues of estimation of labour productivity in the Czech higher education institutions (HEIs) and also at the Faculties of Economics of the Czech HEIs. We focus on the period between the years 2006 and 2010. At first, we analyze the influence of labour productivity on the level of average wages of academic staff in 2010. In this case, we consider that the labour productivity consist of two parts – teaching productivity (the total number of students adjusted by the coefficient of economical difficulty per academic staff) and research productivity (the total number of publication points per academic staff). Secondly, we compare the changes between teaching productivity in the period between the years 2006 and 2010 and the changes between average wages adjusted of average inflation rate at the level of HEIs and at the level of the Faculties of Economics.

Key Words

Higher education institutions, correlation, labour costs, labour productivity, productivity in non-market industries

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Introduction

In 2009 the White Paper on Tertiary Education[1] was brought out and the discussion of tertiary education reform has significantly gained on importance since then. It brought questions of quality of higher education institutions (hereafter: HEIs) and academic staff as well. That is why we decided to present analyses dealing with labour productivity and labour costs at the Czech HEIs and at the Faculties of Economics.

According to The Principles and Rules of Funding of HEIs[2], public funds (subsidies from the Ministry of Education, Youth and Sports for educational activities of HEIs) are allocated to the level of HEIs and not to the level of faculties. Allocation of the university budget to individual faculties fully depends on autonomous decision of the Academic Senate of HEI (the Senate has to confirm the Rector's proposal of the HEI's budget[3]).

The main goal of the paper is to evaluate whether the allocation of HEIs' budgets on faculties leads to the significant relation between teaching and research performance of academic staff on one hand and average wages on the other hand at faculties related on economic branches of study.

Measurement of performance and productivity in non-market industries is a very demanding issue. While the productivity in *market* industries can be considered as a ratio of sales (adjusted of changes in own-produced inventories) to employment, in *non-market* industries we cannot measure sales as an output. As a key reference to an issue of non-market-industry productivity we consider Atkinson Review (ONS, 2005); chapter 9 is devoted to education. Consequences of differences between market-industry productivity and non-market-industry productivity including estimates of production function for non-market industries are presented by Simpson (2006). However, both Atkinson and Simpson use British data and in relation to education they take into account mainly basic and secondary education. Productivity in higher education and approaches to its measurement are defined by Gates and Stone (1997). As most important in this paper we consider terminological differences between terms *efficiency* and *effectiveness*. Jablonsky (2011) analysed the efficiency of teaching and research activities at the level of departments using DEA methodology. Huzvar and Rigova (2012) used DEA methodology for analysis of relations between academic process and funding of public HEIs. Finally, relation between productivity and policy making is introduced by Callan (2007).

The aims of the article are (i) to estimate the relation between average wages and academic performances and (ii) to compare differences between changes in labour productivity and changes in labour costs (represented by the average wages) both at the Czech HEIs and at the Faculties of Economics between the years 2006 and 2010.

Material and Methods

For the analysis we use data from the Ministry of Education, Youth and. This data set includes data on average wages of academic staff, number of academic staff (MŠMT, 2012a), average number of students (MŠMT, 2012b) and the sum of the publication points (called "RIV points") using the "Methodology of Evaluation of Research Institutions Results and of Evaluation of Finished Programmes 2011" (RVVI, 2011). All the analyses

1 http://www.msmt.cz/reforma-terciarniho-vzdelavani/bila-kniha?highlightWords=white+paper+tertiary

2 The Principles and Rules of Funding of HEIs, Czech language (2012d): http://www.msmt.cz/ekonomika-skolstvi/zasady-a-pravidla-financovani-verejnych-vysokych-skol-pro

3 Paragraph 9, the Law on Higher Education Institutions (2012c): http://www.msmt.cz/file/22282

are presented only on the public HEIs excluding artistic HEIs which are the outliers[4]. Colleges are not included into the analysis. Due to the lack of the dataset needed for the analysis we had to exclude the Faculty of Economics of University of South Bohemia in České Budějovice and two newest non-university HEIs[5].

Firstly, we would like to find out if the average wage of the academic staff is the function of labour productivity and if there is a correlation between these variables. Labour productivity in this case consists of two self-independent parts – teaching (number of student adjusted by the coefficient of economical difficulty per academic staff) and research (RIV points per academic staff).

Multiple regression and multiple correlation coefficients[6] were used for the analysis. The analysis is based on the hypothesis that changes in the dependent variable y (average wage) are caused by two independent variables x_1 and x_2 (teaching productivity and research productivity) which is presented by the formula:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \quad (1)$$

By using the method of least squares we can estimate the multiple regression function

$$Y = b_0 + b_{yx1.x2} x_1 + b_{yx2.x1} x_2 \quad (2)$$

For the discussion about the relation between the variables the multiple correlation coefficient $r_{yx1.x2...xp}$ and the coefficient of determination R^2 were used.

The second part of the paper is focused on the analysis of competitiveness of the HEIs and Faculties of Economics by using the condition modified to the non-market industry

$$C_1/Y_1 < C_0/Y_0, \quad (3)$$

where C…labour costs[7]

Y…number of students

After an adjustment we can state

$$C_1/C_0 < Y_1/Y_0, \quad (4)$$

which could be interpreted as a requirement of slower increase of labour costs in comparison with the change of number of students.

After the division of both parts of the inequation by the labour force index represented by the index of number of academic staff, we get

$$C_1/C_0 : L_1/L_0 < Y_1/Y_0 : L_1/L_0, \quad (5)$$

and after the algebraic adjustment

$$C_1/L_1 : C_0/L_0 < Y_1/L_1 : Y_0/L_0. \quad (6)$$

It means that average labour costs should increase more slowly than labour productivity[8]. Alternatively, we can consider compensation of employees as C, but in short term we can suppose the constant ratio of social contributions to wages and salaries. It implies that the inequation (4) expresses the relation between average wages and labour productivity. Since we estimate real labour productivity by using natural indicator, the average wage has to be real too. It is necessary to take into account inflation represented by consumer price index[9].

4 The average coefficient of economical difficulty of the artistic HEIs reaches 5.9. It is much higher than the rest of the HEIs.

5 We do not have RIV points of the non-university HEIs .

6 For more information see Hindls et al (2004).

7 Labour costs are broadly described in Jílek, Moravová (p. 129, 2007).

8 The competitiveness concept is only one of the possible approaches. In the case of an increase of the quality of education (e.g. employment more qualified academic staff) the condition would be applied vice versa.

9 See Hindls et al. (p. 381, 2004).

Results

Higher Education Institutions

For the analyses we use the data on number of students of the HEIs, the coefficient of economical difficulty, number of academic staff, average wage, RIV points (see Table 1 and Table 2).

Firstly, we discussed whether average wage is the function of labour productivity represented by teaching productivity (x_1) and research productivity (x_2).

$$y = 19\,069.8 + 303.92x_1 + 76.62x_2 \quad (7)$$
$$(4.64) \quad (3.31 \quad (4.29)$$

From the results we can say that increase in teaching productivity (the increase of one student per academic staff) evokes increase in average wage of 303.92 CZK. One point of increase in RIV points per person leads to increase in the average wage of 76.62 CZK.

The values of characteristics are as follows:

$$R^2 = 0.561,\ r_{x1x2} = -0.37,\ r_{yx1} = 0.53,\ r_{yx2} = 0.29$$

	2006			2010			RIV points
	Students	Average coeff. of the economical difficulty	Academic staff	Students	Average coeff. of the economical difficulty	Academic staff	
CTU	22 747	1.815	1 411.7	22 517	1.865	1 500.4	211 795.95
CULS	16 748	1.611	498.7	20 877	1.584	586.0	39 260.67
USB	9 984	1.530	566.9	12 593	1.506	588.0	65 244.23
MU	32 483	1.417	1 335.1	39 500	1.406	1 414.9	197 255.59
MENDELU	8 769	1.881	416.6	10 440	1.758	507.4	37 075.97
UO	8 485	1.458	354.3	9 967	1.505	446.8	23 416.61
SU	5 524	1.253	214.5	8 811	1.243	290.9	12 795.60
TUL	8 178	1.433	516.0	9 453	1.404	549.9	25 652.96
UHK	7 303	1.372	351.7	8 910	1.438	388.8	10 505.59
UJEP	9 106	1.669	395.5	10 575	1.663	458.0	13 999.44
CU	46 101	1.256	3 219.3	49 775	1.238	3 465.3	513 337.71
UPA	8 567	1.503	467.4	10 604	1.485	513.0	56 924.88
PU	18 887	1.688	1 034.9	21 935	1.631	1 143.3	122 834.71
TBU	9 906	1.555	309.4	13 113	1.617	396.5	22 529.43
UVPS	2 552	3.164	221.8	2 919	3.162	259.3	18 838.34
VŠB-TUO	21 451	1.509	910.0	22 353	1.498	1 016.3	52 307.64
VŠE	16 012	1.084	566.3	19 271	1.089	582.5	24 029.97
ICT	3 973	2.745	416.9	3 647	2.721	414.5	79 556.49
BUT	20 736	1.701	971.2	22 211	1.690	997.6	134 933.71
UWB	15 650	1.301	764.6	16 469	1.360	822.1	62 430.50

Tab. 1: Number of students, the average coefficient of economical difficulty, number of academic staff, RIV points, public HEIs, 2006 and 2010[10]

10 All the abbreviations are described in appendix.

From the results and the t-statistics (presented under the regression model) we can see that both the variables are significant (5 % level of significance). There is positive correlation between average wage and teaching productivity and there is positive correlation between average wage and research productivity. It means that increase in teaching productivity (represent by students per academic staff) causes the increase in average wage and increase in research productivity cause the increase in average wage as well. There is no multicollinearity[11] (there is weak negative correlation between teaching productivity and research productivity, which means that increase in teaching productivity cause decreasing at the research productivity). It means that the model is estimated right. It is necessary to note that this model presents only part of the average wage.

The second part of the analysis focuses on the average labour costs (represent by real average wage) and teaching productivity (measured as the ratio of students adjusted by the coefficient of the economical difficulty per academic staff) among Czech HEIs between the years 2006 and 2010.

From the results (see table 3) one can see that there are some differences in teaching productivity and average labour costs among 20 Czech HEIs. The biggest difference between teaching productivity and labour costs during the period 2006 and 2010 was achieved at the Institute of Chemical Technology Prague (ICT). The total gap in 4 years was about 19 per cent. On the other hand teaching productivity increased more quickly than labour costs especially at the University of Hradec Králové (UHK). Teaching productivity increased of 15.68 per cent in the period in question. Average labour costs at the University of Hradec Králové decreased of 12.38 per cent.

	average wage	
	2006	2010
CULS	43 085	48 654
ICT	35 218	43 697
MU	36 528	42 958
CTU	35 988	40 677
BUT	35 267	38 986
VŠE	34 411	38 239
MENDELU	34 205	36 547
UPA	33 887	36 152
PU	30 136	35 849
CU	29 020	35 424

	average wage	
	2006	2010
SU	30 363	35 161
VŠB-TUO	34 209	35 155
USB	29 830	34 625
UO	29 401	34 317
TBU	31 378	33 840
UJEP	27 977	33 165
UWB	30 718	33 135
TUL	25 606	32 321
UVPS	29 707	30 474
UHK	28 854	28 340

Tab. 2: Average wage, public HEIs, 2006 and 2010

When we compare this result with the first estimation presented in Fischer, Vltavská (2011) which was done for the period between the years 2004 and 2009 we can see that the biggest difference between teaching productivity and labour costs during the period in question was achieved at the University of Ostrava. The total gap in 5 years was about 31 per cent. On the other hand teaching productivity increased more quickly than labour costs especially at the University of Economics in Prague. Teaching productivity increased of 23.81 per cent in the period in question. Average labour costs at the University of Economics increased of 6.82 per cent.

11 5 % level of significance

	costs	productivity	difference		costs	productivity	difference
UHK	-12.38	15.68	28.6	CULS	0.74	4.32	3.58
VŠE	-0.87	17.49	18.36	VŠB-TUO	-8.33	-7.38	0.94
UPA	-4.83	11.42	16.25	MENDELU	-4.69	-8.66	-3.97
USB	3.55	19.76	16.21	PU	6.12	1.59	-4.53
SU	3.31	16.73	13.43	CTU	0.83	-4.29	-5.12
TBU	-3.79	7.48	11.27	UJEP	5.75	-0.08	-5.83
MU	4.91	13.88	8.97	TUL	12.60	6.31	-6.29
UVPS	-8.49	-2.27	6.22	UO	4.13	-3.90	-8.03
UWB	-3.77	2.33	6.10	CU	8.89	-1.11	-10.01
BUT	-1.38	3.62	5.00	ICT	10.69	-8.50	-19.19

Tab. 3: Change in real teaching productivity and average real labour costs, public HEIs (2006 – 2010, annual growth, %)

Faculties of Economics

The dataset used for the analyses contain number of students of the Faculties of Economics of public HEIs, the average number of academic staff, average wage, RIV points (see Table 4 and Table 5).

First part of the analysis is devoted to the analyses of the relationship between teaching productivity (x_1) and research productivity (x_2).

$$y = 14\,085 + 508.4x_1 + 67.6x_2 \quad (8)$$
$$(1.87) \quad (1.24) \quad (2.81)$$

We can conclude that the increase in the education part of teaching productivity by one causes the increase in average wage by 508.4 CZK. One point of increase in RIV points per person leads to the increase in the average wage by 67.6 CZK (both under the condition of ceteris paribus).

The values of characteristics are as follows:

$$R^2 = 0.37,\ r_{x1x2} = -0.072,\ r_{yx1} = 0.56,\ r_{yx2} = 0.21$$

The t-statistics (presented under the regression model) show that variable "teaching productivity" is statistically significant at 10 % level of significance. A weak negative correlation between teaching productivity and research productivity was traced. That means that an increase in the teaching productivity caused a decrease in the research productivity represented. On the other hand, there is a positive correlation between average wage and the teaching productivity and average wage and research productivity. One can see the link between the results of the HEIs and the Faculties of Economics. There is no multicollinearity (10 % level of significance).

Faculty	University	2006 Students	2006 Academic staff	2010 Students	2010 Academic staff	RIV points
of Social Sciences	CU	3 128.5	125.8	4 104.5	137.3	14 136
of Social and Economic Studies	UJEP	2 080.5	55.6	2 199.5	67.2	321
of Economics and Administration	MU	3 520.0	86.6	4 452.5	92.8	3 060
School of Business Administration in Karvina	SU	2 635.0	95.0	4 384.5	107.6	2 581
of Economics	UWB	2 208.5	62.6	2 311.5	61.2	492
of Economics	TUL	1 386.0	71.4	2 080.5	83.1	2 037
of Economics and Administration	UPA	2 381.5	69.4	2 638.5	78.5	3 925
of Business and Management	BUT	2 185.5	63.7	2 758.0	81.2	1 961
of Economics	VŠB-TUO	5 594.0	175.0	6 539.0	175.5	4 995
of Management and Economics	TBU	3 197.0	72.3	3 418.5	83.9	2 927
of Finance and Accounting	VŠE	2 576.0	79.5	3 176.0	81.6	5 392
of International Relations	VŠE	3 835.0	170.3	4 712.5	171.8	5 252
of Business Administration	VŠE	3 260.5	91.5	3 778.0	105.9	3 435
of Informatics and Statistics	VŠE	2 575.5	111.1	3 332.0	100.3	4 809
of Economics	VŠE	2 231.5	55.8	2 571.5	65.2	3 936
of Management	VŠE	1 284.5	39.5	1 436.5	38.6	1 201
of Economics and Management	CULS	7 144.0	168.6	9 462.0	185.7	5 276
of Business and Economics	MENDELU	2 831.5	96.9	3 658.0	113.9	5 636

Tab. 4: Average number of students, average number of academic staff, RIV points, Faculties of Economics, 2006 and 2010

The productivity analysis represents the second part of the paper. We estimated the average labour cost (real average wage) and teaching (labour) productivity (the ratio of students adjusted by the coefficient of the economical difficulty per academic staff) among the Faculties of Economics between the years 2006 and 2010.

When comparing the development of teaching productivity and average labour costs, the differences between the individual quantities may take the form of percentage. This proved better for our purposes since it clearly illustrates the change in the growth. In 2010, the highest average wage is reached at the Faculty of Economics and Management of the Czech University of Life Sciences Prague (CULS), followed by the Faculty of Economics and Administration of Masaryk University and the Faculty of Finance and Accounting of the University of Economics, Prague (see Table 5). On the other hand, the wage is the lowest at Faculty of Economics of the West Bohemia University (UWB). Also some methodological issues mentioned above such as additional workloads complicate the analysis and interpreting of its results.

		average wage	
Faculty	HEI	2006	2010
of Economics and Management	CULS	43 963	54 551
of Economics and Administration	MU	39 288	44 654
of Finance and Accounting	VŠE	38 933	43 823
of Economics and Administration	UPA	38 353	38 214
of Business Administration	VŠE	34 919	37 060
of Economics	VŠE	34 030	36 554
of Informatics and Statistics	VŠE	32 374	36 442
of Business and Economics	MENDELU	35 634	36 105
of Management	VŠE	35 326	35 682
of Social Sciences	CU	30 258	35 096
School of Business Administration in Karvina	SU	26 585	34 769
of International Relations	VŠE	30 361	34 482
of Economics	VŠB-TUO	31 941	33 936
of Economics	TUL	27 559	32 614
of Social and Economic Studies	UJEP	29 477	32 570
of Business and Management	BUT	28 837	31 074
of Management and Economics	TBU	26 080	28 079
of Economics	UWB	32 472	27 335

Tab. 5: Average wage, Faculties of Economics, 2006 and 2010

Table 6 presents the results of productivity analysis. One can see that there are some differences in teaching productivity and average labour costs among Faculties of Economics. At almost all Faculties of Economics, increase in teaching productivity is higher than in average wages. It could be explained by three causes. Firstly, the increase in number of students recorded between 2006 and 2010 had started at the beginning of 2000s. Secondly, due to the economic recession and fiscal restrictions the total budget for public universities decreased from 2009. Thirdly, the increase in number of students is realized mainly in economic branches of studies. But, there is a difference between individual Faculties of Economics. The highest difference between teaching productivity and real labour costs is higher than 40 percentage points (Faculty of Informatics and Statistics, University of Economics, Prague), but, on the other hand, at two faculties the decrease in productivity is higher than decrease in real labour costs.

Faculty	HEI	Costs	Productivity	Difference
of Informatics and Statistics	VŠE	0.42	43.24	42.82
of Economics	UWB	-24.90	7.12	32.02
School of Business Administration in Karvina	SU	16.67	46.86	30.19
of Management	VŠE	-9.89	14.34	24.23
of Economics	TUL	5.57	29.03	23.45
of Economics	VŠB-TUO	-5.22	16.59	21.81
of International Relations	VŠE	1.32	21.83	20.52
of Finance and Accounting	VŠE	0.41	20.15	19.74
of Business and Economics	MENDELU	-9.61	9.88	19.49
of Social Sciences	CU	3.47	20.19	16.72
of Economics and Administration	MU	1.39	18.01	16.62
of Economics and Management	CULS	10.69	20.26	9.57
of Economics and Administration	UPA	-11.11	-2.00	9.12
of Business Administration	VŠE	-5.32	0.08	5.40
of Business and Management	BUT	-3.87	-1.01	2.87
of Economics	VŠE	-4.18	-1.45	2.72
of Management and Economics	TBU	-3.95	-7.88	-3.92
of Social and Economic Studies	UJEP	-1.43	-12.47	-11.04

Tab. 6: Change in real labour productivity and average real labour costs, Faculties of Economics (2006 – 2010, annual growth, %)

Discussion

At the analysis of relations between wages and productivity of the *faculties* we can see significantly lower level of R^2 comparing to the analysis at the level of (whole) HEIs. From our point of view it is possible to explain lower R^2 by several reasons. Firstly, there could be some redistributive processes within HEIs (support of weaker faculties). Secondly, there are some methodological issues which can influence the average wage. For example, from some research projects the benefits from staff has the form of additional money (bonuses), from other projects the benefits has the form of additional money and also the additional workload. If we increase both wage and formal workload, the average wage will not raise. Thirdly, the total subsidy for the student is influenced not only by the coefficient of economic difficulty, but also by so-called qualitative and performance indicator ("VKM"). Fourthly, using RIV points we measure the research output, while the average wage is influenced by research inputs (institutional and specific support of research). It means that there could be a weak correlation between inputs and outputs. Finally, maybe the RVVI Methodology (RVVI, 2011) is not so good for comparison of research performance among Faculties of Economics.

If we compute research productivity of the Czech HEIs (at the level of HEIs) we would conclude that the research productivity is higher in more heterogeneous institutions (Charles University, Masaryk University) and in institutions which are more focused on technical and science branches (Czech Technical University). On the other hand, more homogeneous (University of Economics, Prague) and HEIs oriented on humanities and social sciences (University of Hradec Kralove, Jan Evangelista Purkyne University in Usti) are less efficient. These conclusions are in accordance to the results of Huzvar and Rigova (2012).

The results can be partly explained by the method of evaluation of research activities (so-called coffee-mill) by RVVI (2011) which prefer technical and science research.

Conclusion

In this paper we presented two parts of analysis of labour productivity at higher education institutions. Firstly, variance in average wage at 20 HEIs could be explained by variance in labour productivity divided into teaching productivity (measured by adjusted number of students per academic staff) and research productivity (RIV points per academic staff). By this relation, where number of students is adjusted by the coefficients of economic difficulty, 56.1% of variance could be explained. In comparison with the results for the period between the years 2004 and 2009 (66.5 %) we explained smaller part of differences in average wages at HEIs.

From the point of view of the Faculties of Economics the variance in average wage could also be explained by variance in teaching productivity and research productivity. This model explained only 37 % of the variance which was a smaller part of variance of average wage than a similar model of public HEIs. The underlying reasons could be detected in some redistribution processes, methodological issues, influence of qualitative indicators (so-called VKM), weak correlation between research money and research output and unsuitability of RVVI Methodology for comparisons among faculties of economics.

Second part of the analysis focused on the comparison of teaching productivity and labour costs of the Faculties of Economics. Almost all Faculties showed higher increase in teaching productivity than in labour costs. The highest difference was achieved at the Faculty of Informatics and Statistics, University of Economics in Prague (42.82 %). Unfortunately, as a reverse part of the pressure on teaching productivity we should consider the issues of quality of an educational process.

Analyses of HEIs gain more importance these days. We will continue our work in this area analysing the relationship between the structure of academic staff and the structure of RIV points for instance.

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Appendix

Abbreviation	University
ČTU	Czech Technical University in Prague
CULS	Czech University of Life Sciences Prague
USB	University of South Bohemia in České Budějovice
MU	Masaryk University
MENDELU	Mendel University in Brno
UO	University of Ostrava
SU	Silesian University in Opava
TUL	Technical University of Liberec
UHK	University of Hradec Králové
UJEP	Jan Evangelista Purkyně University in Ústí nad Labem
CU	Charles University in Prague
UPA	University of Pardubice
PU	Palacký University Olomouc
TBU	Tomas Bata University in Zlín
UVPS	University of Veterinary and Pharmaceutical Sciences Brno
VŠB-TUO	VŠB – Technical University of Ostrava
VŠE	University of Economics, Prague
ICT	Institute of Chemical Technology Prague
BUT	Brno University of Technology
UWB	University of West Bohemia

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EFFICIENCY OF KNOWLEDGE TRANSFER THROUGH KNOWLEDGE TEXTS: STATISTICAL ANALYSIS

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Abstract

Texts are an important way to share and transfer knowledge. In this paper we analyse the impact of a specific form of texts, so called "knowledge texts", on the efficiency of knowledge transfer. The objective is to verify or reject several hypotheses on the relationships among the style of educational texts (standard or knowledge styles), learning outcomes (performance of the students after learning) and subjective evaluation of conformity of working with individual styles of the texts. For this purpose, we carry out experiment with a homogeneous group of the students (n = 41) divided into an experimental group and a control group. We use statistical methods to process the results of the experiments; ability of the students to solve specific tasks and their opinions on readability and understandability of the texts subject to the time spent for learning. Even if we determine statistically significant relationships between the style of texts and accuracy of the problem solving in the experimental group only, the results allow us to improve the experiment and apply the methodology developed in a less structured branch than the Operational Research (Graph Theory) is. The methodology is another benefit of the paper, because it can be applied independently on a particular domain.

Key Words

Knowledge unit, Standard text, Knowledge text, Statistical analysis, Graph theory

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Introduction

Studies on the role and efficiency of educational texts as a form of knowledge transfer are very topical, particularly in pedagogical sciences. Pedagogical researchers are very often focused on measuring the efficiency of education (Tudor, 2012). Teaching methods are an important issue in measuring their efficiency (Maňák, Janík 2009; Starý, Chvál, 2009). Vališová and Kasíková (2011) describe several teaching methods. Working with text is one of them. Starý and Chvál (2009) describe models of quality and efficiency on pedagogical level. However, these models have different characteristics from the systems approach models; e.g. Data Envelopment Analysis (Šubrt, 2011). Dömeová et al. (2008) use the systems approach for knowledge modelling. Also this approach is used by Glava and Glava (2011); they combine didactic modelling with an analytic point of view.

Teaching texts and textbooks are used in many cases during lessons but also during home studying and preparing. Texts and textbooks have many significant functions and they have to be analyzed in detail. For this reason, experiments are often used in order to clarify the importance of some properties and parameters of textbooks (Mikk, 2007). Tannenbergová (2009), Dobrylovský (2009) or Hodis (2003) focused on the analysis of the pedagogical texts. The observed aspects are, for example, the measuring of difficulty, analysis of terminology, didactic content of text, or information density, etc. These aspects are measured and expressed by quantifiers.

Prasad and Ojha (2012) present an experiment on comparing three ways of transferring knowledge (text, table and graphs) and then evaluating their efficiency. They use the speed of understanding and accuracy of responses as criteria. Based on their experimental data they discovered that there is no ideal form of knowledge transferring because of antagonistic criteria. The fastest way (the graphs) is the least accurate one and vice versa, the most accurate way (the text) is the slowest one.

Kools et al. (2006) deal with a similar problem; how to evaluate the effect of graphic organizers on the comprehension of a specific educational text and compared subjective with objective comprehension measures. They found significant positive impacts of graphic organizers at four levels of objective comprehension as indicated by open comprehension questions. Obviously, comprehension is also influenced by the graphical way of presentation of knowledge in texts.

Lee and Segev (2012) stress the impact of a specific form of declarative representation of knowledge; knowledge maps (K-maps) in learning and e-learning. In contrast with the traditional approaches to the construction of such maps by human experts, they propose a text mining technique to create it automatically. For this purpose they use the TF/IDF algorithm to extract keywords and then they develop the K-maps in the current domain based on the ranking pairs of keywords according to the number of their occurrences in a sentence and the number of words in a sentence. Auxiliary experiments show that the K-map learning identifies core ideas much more smoothly compared to the standard document learning. Finally, the K-maps are a promising and commonly used tool in more areas of working with knowledge and people, e.g. in human resources management or identification of talents (Kolman, 2008).

The objective of the paper is to analyze the impact of different styles of educational texts on the performance provided by the students. In particular, we focus on two ways of the text presentations:

- standard text, as usually appears in textbooks;
- knowledge text, redesigned by using the methods of Knowledge Engineering.

We concentrate on accepting or rejecting the following main hypotheses:

The students provide significantly better performance using the knowledge text rather than the standard one. They solve the problems more successfully. Also, the style of the knowledge text is more comfortable for them to work with.

We carried out an experiment with the students of the Czech University of Life Sciences Prague. Two groups of students worked with the standard and knowledge educational texts and solved problems in the area of Mathematical Methods in Economics. Objective results and subjective evaluation of the texts received from the students were processed by advanced statistical methods. That allowed us to decide on the validity of the above-mentioned hypotheses.

Materials and Methods

Knowledge texts

In this study, we understand the "knowledge text" as a specific form of educational text, which contains knowledge in an explicit form.

In particular, apart from the necessary data and information, there is also procedural knowledge (usually represented by a production rule or a knowledge unit). The knowledge is expressed in a natural language in the knowledge text.

Dömeová, Houška and Beránková (2008) suggested a definition of the "knowledge unit" (KU) as a special, well-structured type of a piece of knowledge that contains one production rule related to the successful solving an elementary problem. Formally, a knowledge unit can be expressed as

$$KU = \{X, Y, Z, Q\}, \quad (1)$$

where X stands for a problem situation,

Y stands for an elementary problem being solved within the framework of the X problem situation,

Z stands for an objective of solving the elementary problem,

Q stands for a successful solution of the elementary problem (result).

The elementariness of knowledge is predetermined by the elementariness of the problem. The elementary problem is a problem or a part of a complex problem which is impractical to be further divided into more simple sub-problems. Criteria for assessing the degree of elementariness are defined by the knowledge user, because they depend on his or her ability to understand and apply the rules included in elementary knowledge. This is in conformity with Zack´s definition of knowledge units (Zack, 1999).

Knowledge unit may be expressed as a whole in a natural language. As mentioned above, there is no exclusivity; each part of the unit has several facultative ways of expression and almost all of their combinations are feasible. The basic form of knowledge unit expression derived by systems approach is defined as follows:

If we want to solve an elementary problem Y in the problem situation X to reach the objective Z, then we should apply the solution Q.

To create the knowledge text from the standard one, we use the following procedure (Dömeová, Houška, Beránková, 2008).

- Step 1: Select a standard text for transformation.
- Step 2: Analyze the text to identify knowledge units included.
- Step 3: Express the knowledge units in an analytical form.
- Step 4: Convert the analytical form of knowledge unit into a natural language.

Research sample

The experiment was accomplished with 41 students in total. All participants study the programme Public Administration and Regional Development at the Czech University of Life Sciences Prague. The participants were divided into two groups: A (experimental group) and B (control group). The groups were balanced subject to the following criteria: age, gender, prior qualification, prior formal education and mathematical skills measured by the study results in the study subject Mathematical Methods in Economics and Management reached in the past.

Design of the experiment

The experiment is observed by the administrator who is responsible for ensuring the same conditions for all participants, recording the outputs from the participants and doing auxiliary tasks during the experiment (measuring the time, distributing data sheets and questionnaires, etc.). In case of doubts he answers the questions from the participants. The experiment was realized within two weeks.

Week 1. The group A receive the knowledge text, the group B the standard educational text to study the methods to solve the problem. The following aspects are observed:

- Duration of studying the texts measured by the time necessary to understand it. Due to psychological reasons (to avoid the disturbance of the participants), this aspect is monitored covertly. The start is common at the same time, the end is announced by the student individually to the administrator.

- Quality of understanding measured by the ability of the students to solve a specific problem using their new knowledge. Two-value measure "Pass"/"Fail" is used.

Week 2. The group A receive the standard educational text, the group B the knowledge text to study the methods to solve the problem. Again, the texts deal with the same topic, but the particular algorithm differs from the one in the Week 1. Except Duration of studying the texts and Quality of understanding measured identically as in the Week 1, also we observe subjective opinions of the students on the comfortableness of working with standard and texts. In further text, we use the variables denoted as follows.

- t_1 ... time of learning - week 1 (s)
- t_2 ... time of learning - week 2 (s)
- acc_1 ... accuracy of the problem solving (number of users solved the problem correctly) - week 1
- acc_2 ... accuracy of the problem solving (number of users solved the problem correctly) - week 2

The process of the experiment is depicted in Figure 1.

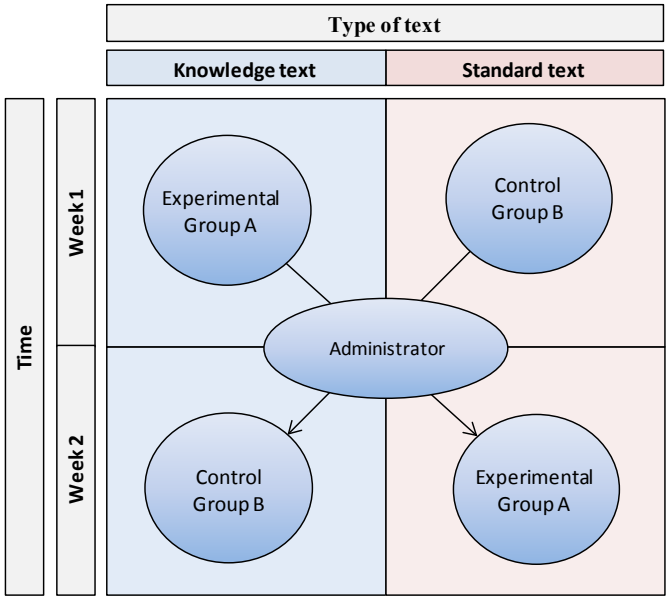

Figure 1: Design of the experiment

Statistical methods used

We use the following statistical methods to analysing the data received from the experiment. In details, all methods are described in statistical literature, e.g. Lindseuy (2009) or Peck and Devore (2012).

Basic descriptive statistics

The statistical characteristics are called numeric values that provide us the basic information about the statistical properties of the population. For this work we use the characteristics that describe the measure the central tendency and dispersion of the data.

We use arithmetic mean, median, variance and standard deviation to describe the sample in our experiment. The mean value is observed because of the differences in duration of comprehension (measured in units of time) in normal and knowledge texts. Frequencies are used for description of execution, correctness and accuracy of the problems solved.

Parametric tests

Hypotheses are regarding the value of one or more parameters of the distribution. We assume a normal distribution of random tested variables. These tests are numerically difficult, but they have a good power of the test. Unknown parameter values between the two populations can be measured by two-sample parametric tests.

The experiment is based on two groups (A and B). The former works with knowledge text and the latter works with normal texts during the first part of the testing procedure. The role of the groups and type of texts are exchanged during the second part of the experiment (see Figure 1). Some chosen aspects are observed in each group. Therefore , two-sample F test, two-sample t-test, Behrens-Fisher test, Shapiro-Wilk W test and two-sample test about relative frequencies are all used in the experiment for finding differences between working with different type of texts.

Correlation analysis of qualitative variables

Contingency is a relationship of two or more quality characteristics, of which at least one is a sign of the plural. Characters can be organized into contingency tables. Each of

the characters is divided into k (rows) and m (columns) groups, where k is the number of permutations of the first character and m is the number of permutations of the second character. Chi-square test is used for testing the independence in the contingency table.

In our experiment we supplemented objective aspects also by subjective aspects. Subjective aspects are subjective expression and experience with solving the same problem. We analyze these aspects together and in association with execution, correctness and accuracy of the problems solved.

All calculations were carried out in the Statistica, version 10.

Results

We use the above-given statistical methods to find out, whether the users working with knowledge texts solve problems better than the others. Also we test the influence of the type of text on the performance of the users.

Week 1 - Data Analysis

Descriptive statistics - time of learning

We provide basic descriptive statistics for the variable t_1 for the experimental group A and control group B. The users from the group A work with the knowledge text, group B with the standard text. The statistics are summarized in Table 1.

	n	Mean	Median	Min	Max	Variance	Standard deviation
Group A	19	518.42	512.00	8.00	1014.00	79730.70	282.37
Group B	22	169.23	136.50	10.00	421.00	14459.90	120.25

Table 1: Descriptive statistics, variable: t_1, week 1

Obviously, the mean value as well as the variance and the maximum value are higher for the group working with the knowledge text. Quartiles and medians for both groups are depicted by the box plots, see Figure 2. There are no outliers in the dataset of the variable t_1 for any group.

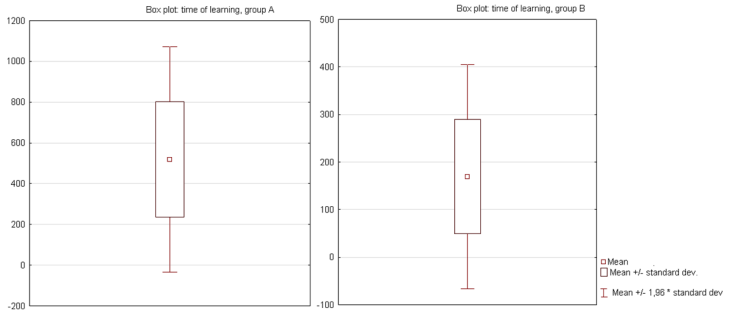

Figure 2: Box plots, variable t_1, week 1

Distribution of frequencies - accuracy of the problems solved

We determine the distribution of frequencies for the variable acc_i for both groups A and B and i-th week. We use the bivalent scale, where

- "1" means "the problem was solved correctly";
- "0" means "the problem was solved with an error".

The statistics are summarized in Table 2.

	Group A		Group B	
Category	Frequency	Cumulative Frequency	Frequency	Cumulative Frequency
0	3	3	10	10
1	16	19	12	22

Table 2: Distribution of frequencies, variable acc_1, week 1

Group A reached a higher frequency of correct answers than the group B. The users working with the knowledge text achieved about 30% more accuracy than the users working with the standard text.

Testing of the statistical hypotheses - time of learning

For this purpose, we use parametric tests. Thus, we verify the normality of distributions for the variables tested in the experimental group A and the control group B. Shapiro-Wilk W test is used, see Table 3.

Null hypothesis H_0	The distribution of the basic set t_1 is normal	
Alternative hypothesis H_A	The distribution of the basic set t_1 is not normal	
Results for the group	p-value	α
Group A	0.82945	0.05
Group B	0.05287	0.05

Table 3: Normality of distribution test, variable: t_1, week 1

In any case, we cannot reject the null hypothesis; p-value > α for the groups A and B. It allows us to suppose that the assumption of normality of distribution is valid. Also the above-mentioned results can be confirmed visually, see the histograms in Figure 3.

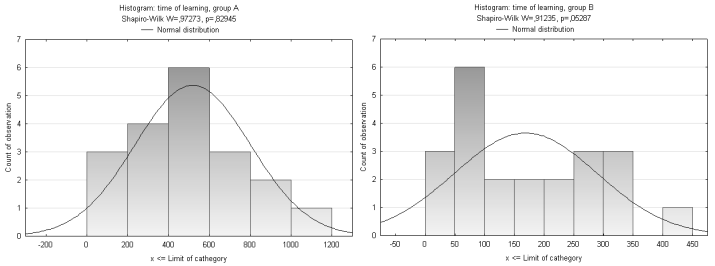

Figure 3: Histograms for the variable t_1, group A (left), group B (right), week 1

Two-sample tests of the significance of differences of sample means for t_1 between the groups A and B

Firstly we calculate two-sample F-test for the variance, see Table 4.

Null hypothesis H_0	The variance of the variable t_1 are equal (α = 0.05)	
Alternative hypothesis H_A	The variance of the variable t_1 are not equal	
Statistics	p	a
Group A vs. Group B	0.00032	0.05

Table 4: Two-sample F-test for the variance, variable: t_1, week 1

As $p < \alpha$ on the level of significance α = 0.05, we reject the null hypothesis H_0. For further calculations we suppose that the variances of the data sets are significantly different.

In order to test the hypothesis on the equality of means we use the Behrens-Fisher test. The results are as follows.

Null hypothesis H_0	The means of the variable t_1 are equal ($\alpha = 0.05$)	
Alternative hypothesis H_A	The means of the variable t_1 are not equal	
Statistics	p	α
Group A vs. Group B	0.00005	0.05

Table 5: Equality of sample means test, variable: t_1, week 1

As $p < \alpha$ on the level of significance $\alpha = 0.05$, we reject the null hypothesis H_0. The statistically significant difference between sample means was confirmed.

Week 2 - Data Analysis

Descriptive statistics - time of learning

Also for the week 2 we provide basic descriptive statistics for the variable t_2. In this week, the experimental group A was working with the standard text and the control group B was working with the knowledge text. The basic statistics are summarized in Table 6.

	n	Mean	Median	Min	Max	Variance	Standard deviation
Group A	19	393.68	296.00	7.00	1192.00	108614.10	329.57
Group B	22	412.00	383.50	62.00	935.00	62810.90	250.62

Table 6: Descriptive statistics, variable: t_2, week 2

The mean value and the minimum value are higher for the group B working with the knowledge text, the variance and the maximum value are higher for the group A working with the standard text. Quartiles and medians for both groups are depicted by the box plots, see Figure 4. There are no outliers in the dataset of the variable t_2 for any group.

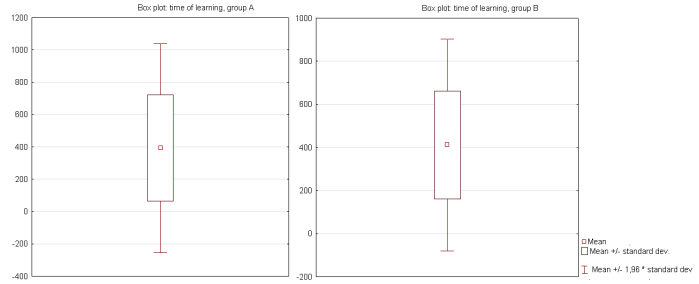

Figure 4: Box plots, variable t_2, week 2

Distribution of frequencies - accuracy of the problems solved

We determine the distribution of frequencies for the variable acc_2 for both groups A and B. Again, the bivalent scale (1 - solved correctly; 0 - solved incorrectly) is used. The statistics are summarized in Table 7.

	Group A		Group B	
Category	Frequency	Cumulative Frequency	Frequency	Cumulative Frequency
0	6	6	6	6
1	13	19	16	22

Table 7: Distribution of frequencies, variable acc_2, week 2

Group B reached a higher frequency of correct answers than the group A. The users working with the knowledge text achieved about 5% more accuracy than the users working with the standard text.

Testing of the statistical hypotheses - time of learning

We use the same approach as for the Week 1. To verify the normality of distributions for the variables tested in the experimental group A and the control group B, we use the Shapiro-Wilk W test, see Table 8.

Null hypothesis H_0	The distribution of the basic set t_2 is normal	
Alternative hypothesis H_A	The distribution of the basic set t_2 is not normal	
Results for the group	p-value	α
Group A	0.05772	0.05
Group B	0.15570	0.05

Table 8: Normality of distribution test, variable: t_2, week 2

In any case, we cannot reject the null hypothesis; p-value > α for the groups A and B. It allows us to suppose that the assumption of normality of distribution is valid. Also the above-mentioned results can be confirmed visually, see the histograms in Figure 5.

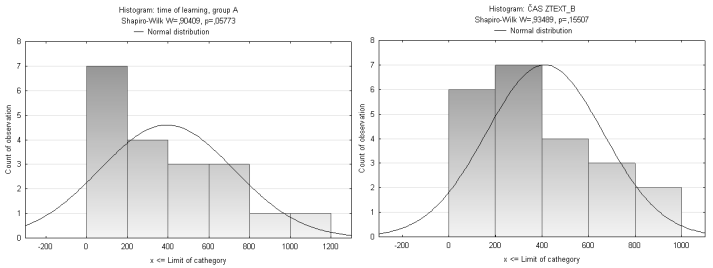

Figure 5: Histograms for the variable t_2, group A (left), group B (right), week 2

Two-sample tests of the significance of differences of sample means for t_2 between the groups A and B

Firstly we calculate two-sample F-test for the variance, see Table 9.

Null hypothesis H_0	The variance of the variable t_2 are equal (α = 0.05)	
Alternative hypothesis H_A	The variance of the variable t_2 are not equal	
Statistics	p	α
Group A vs. Group B	0.22981	0.05

Table 9: Two-sample F-test for the variance, variable: t_2, week 2

As $p > \alpha$ on the level of significance $\alpha = 0.05$, we cannot reject the null hypothesis H_0. For further calculations we suppose that the variances of the data sets are not significantly different.

In order to test the hypothesis on the equality of means, we use the two-sample t test. The results are as follows.

Null hypothesis H_0	The means of the variable t_2 are equal (α= 0.05)	
Alternative hypothesis H_A	The means of the variable t_2 are not equal	
Statistics	p	α
Group A vs. Group B	0.841090	0.05

Table 10: Equality of sample means test, variable: t_2, week 2

As $p > \alpha$ on the level of significance $\alpha = 0.05$, we cannot reject the null hypothesis H_0. We cannot confirm that the difference between the sample means is statistically significant.

Dependence analysis of qualitative variables

We use the dependence analysis of qualitative variables to evaluate a feedback from the participants of the experiment. The feedback questions are as follows:

1. Subjective evaluation of the understandability of individual text styles
   a) Both knowledge and standard texts are understandable for me.
   b) Knowledge text is understandable for me, but the standard one is not.
   c) Standard text is understandable for me, but the knowledge one is not.
   d) Neither knowledge nor standard texts are understandable for me.
2. Prior knowledge of the algorithms tested
   a) I was familiar with both the CPM method and the Dijkstra's algorithm.
   b) I was familiar with the Dijkstra's algorithm only.
   c) I was familiar with the CPM method only.
   d) I was familiar neither with the CPM method nor the Dijkstra's algorithm.

Contingence tables and Chi-square test are being used for this purpose. The *p*-value allows us to confirm or reject the validity of the following hypotheses:

Hypothesis 1: There is no statistically significant dependence between a number of correctly-solved tasks and the prior knowledge of the algorithm tested.

We summarize the results of the experiment in Table 11.

Accuracy / Prior knowledge	CPM and Dijkstra	Dijkstra only	CPM only	None of them
CPM and Dijkstra	6	0	3	1
Dijkstra	6	1	3	1
CPM	1	2	2	0
None of them	8	5	0	2

Table 11: Accuracy of the problem solving subject to the prior knowledge

We calculate the expected frequencies (see Table 12) and the *p*-value. As $p = 0.22235$, we cannot reject the Hypothesis 1 on the level of significance $\alpha = 0.05$ ($p > \alpha$). There is no statistically significant dependence between the prior knowledge of the algorithms and the accuracy of the problem solving.

Prior knowledge \ Accuracy	CPM and Dijkstra	Dijkstra only	CPM only	None of them
CPM and Dijkstra	5.12	1.95	1.95	0.98
Dijkstra	5.63	2.15	2.15	1.07
CPM	2.56	0.97	0.98	0.49
None of them	7.68	2.93	2.93	1.46

Table 12: Accuracy of the problem solving subject to the prior knowledge - expected frequencies

Hypothesis 2: There is no statistically significant dependence between correctly-solved tasks and a subjective evaluation of the understandability of the texts.

We summarize the results of the experiment in Table 13.

Positive understandability \ Accuracy	CPM and Dijkstra	Dijkstra only	CPM only	None of them
Both standard and knowledge texts	6	2	2	0
Knowledge text only	6	1	2	3
Standard text only	5	1	3	1
None of them	4	4	1	0

Table 13: Accuracy of the problem solving subject to the understandability of the texts

We calculate the expected frequencies (see Table 14) and the p-value. As $p = 0.351211$, we cannot reject the Hypothesis 2 on the level of significance $\alpha = 0.05$ ($p > \alpha$). There is no statistically significant dependence between the understandability of the texts and the accuracy of the problem solving.

Positive understandability \ Prior knowledge	CPM and Dijkstra	Dijkstra only	CPM only	None of them
Both standard and knowledge texts	5.12	1.95	1.95	0.98
Knowledge text only	6.15	2.34	2.34	1.76
Standard text only	5.12	1.95	1.95	0.98
None of them	4.61	1.76	1.76	0.88

Table 14: Prior knowledge subject to understandability – expected frequencies

Hypothesis 3: There is no statistically significant dependence between the prior knowledge of algorithms tested and the subjective evaluation of the understandability of the texts.

We summarize the results of the experiment in Table 15.

Positive understandability \ Prior knowledge	CPM and Dijkstra	Dijkstra	CPM	None of them
Both standard and knowledge texts	3	3	4	0
Knowledge text only	1	4	3	4
Standard text only	2	1	5	1
None of them	4	3	3	0

Table 15: Prior knowledge subject to the understandability

We calculate the expected frequencies (see Table 16) and the p-value. As $p = 0.223228$, we cannot reject the Hypothesis 3 on the level of significance $\alpha = 0.05$ ($p > \alpha$). There is no statistically significant dependence between the understandability of the texts and the prior knowledge of the algorithms.

Accuracy / Positive understandability	CPM and Dijkstra	Dijkstra	CPM	None of them
Both standard and knowledge texts	2.44	2.68	3.66	1.22
Knowledge text only	2.93	3.22	4.39	1.46
Standard text only	2.20	2.41	3.29	1.10
None of them	2.44	2.68	3.66	1.22

Table 16: Accuracy of the problem solving subject to the understandability- expected frequencies

Hypothesis 4: There is no dependence between the type of the texts and the accuracy of the problem solving

We summarize the results of the experiment in Table 17.

Problem solved / Type of the text	Week 1		Week 2	
	Correctly	With errors	Correctly	With errors
Knowledge text	16	3	16	6
Standard text	12	10	13	6

Table 17: Accuracy of the problem solving subject to the type of the texts

We calculate the expected frequencies (see Table 18) and the p-values for both weeks. In the Week 1, as $p = 0.041799$, we reject the Hypothesis 4 on the level of significance $\alpha = 0.05$ ($p < \alpha$). There is statistically significant dependence between the accuracy of the problem solved and the type of the text. In the Week 2, as $p = 0.762504$, we cannot reject the Hypothesis 4 on the level of significance $\alpha = 0.05$ ($p > \alpha$). There is no statistically significant dependence between the accuracy of the problem solved and the type of the text.

Problem solved / Type of the text	Week 1		Week 2	
	Correctly	With errors	Correctly	With errors
Knowledge text	12.98	6.02	15.56	6.44
Standard text	15.02	6.98	13.44	5.56

Table 18: Accuracy of the problem solving subject to the type of the texts - expected frequencies

Summary of the statistical analysis

We provide the summary of the statistical analysis separately for individual weeks of the experiment and for the complete experiment.

Week 1

Mean values as well as variances for the variable "time of learning" are significantly different between the experimental group and the control group. There is statistically significant dependence between the type of the texts and the accuracy of the problem solving.

Week 2

Neither mean values nor variances for the variable "time of learning" are significantly different between the experimental group and the control group. Also there is no statistically significant dependence between the type of the texts and the accuracy of the problem solving.

Complete experiment

Based on the analysis of the qualitative variables provided by the participants of the experiment as the feedback from them, we can conclude that

- there is no statistically significant difference between a number of the correctly-solved tasks and the prior knowledge of the algorithms tested;
- there is no statistically significant difference between a number of the correctly-solved tasks and the subjective evaluation of the understandability of knowledge and standard texts;
- there is no statistically significant difference between the subjective evaluation of the understandability of knowledge and standard texts and the prior knowledge of the algorithms tested.

Discussion

After we have compared our approach and results achieved with the approaches and results by other authors, we can explain the reason of our findings, where only one partial characteristic was found as statistically significant. Following Peng and Hengartner (2002), the main proof lies in the literary styles of texts used in our experiment. Literary style is an important characteristic of a text and can be measured objectively using statistical methods to distinguish styles of individual authors. The technique can be even use to recognize the author of an anonymous text (Wan et al., 2012).

Although Peng and Hengartner applied their method to the texts of classic literature (by Shakespeare, Dickens, etc.), also their approach would be helpful to measure the similarity between the standard and knowledge text styles. We assume that subject to very formal structure of any text describing mathematical methods (the CPM method and Dijkstra algorithm, in our case), there are no statistically significant differences between the two styles of text used in our experiment.

This point also could elucidate why our results do not correspond with the findings by Ozuru et al. (2009). They showed the impact of prior knowledge on reading skills and text comprehension. Perspectively, we could use their methodology in a reverse way; not to measure the rate of influencing the text comprehension through the prior knowledge, but to filter the impact of it and actually eliminate the initial differences in the prior knowledge among the participants of the experiment. As Tarchi (2010) showed, similar experiment including statistical analysis (multiple linear regression analysis) could be processed correctly even for such an unstructured branch as the history is.

Conclusion

In this paper we present a methodology how to carry out an experiment to verify the impact of the style of an educational text on learning outcomes and students' performance. We used the methods of statistical analysis and accept or reject several hypotheses formulated. Even though only one partial hypothesis can be accepted, the research opens many new ways to improve the experiment.

In Materials and Methods, we presented a methodology to create the knowledge text from the standard one. In the future work we feel necessary to develop the methodology and the procedure of the knowledge text creation in more details. Also the application domain for the experiment should be selected more carefully; we change our focus on less formalized areas than applied mathematics or operations research are.

The main topic for the future work is to select measures for establishing the metrics to quantify the similarity of standard and knowledge texts covering the same contents, which is

presented by different ways only. This allows us to construct the texts of really different styles to measure the impact of such styles to key variables of the learning outcomes.

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