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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;
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ANALYSIS OF STUDY RESULTS AND THE USE OF E-LEARNING MATERIALS WITHIN DISTANCE EDUCATION

Renáta Kunstová

University of Economics, Prague
kunstova@vse.cz

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Abstract

This paper summarizes the results of analysis which concerns new opened field of study with distance mode of study. The aim of analysis is to evaluate the comparability of full-time and distance mode of study and to answer three research questions. The first question concerns the characteristics of distance students who unsuccessfully ended their study already after the second semester. The second research question focuses on utilization of online tests and lists of control questions. The third question investigates how important are video records of lectures for distance students. The analysis is based on data obtained from the Integrated Study Information System. Results should be taken into account in the coming years, when lecturers will update e-learning study materials and prepare tutorials.

Key Words

activity monitoring, distance mode of study, e-learning, higher education, interactive element, online test, video record of lecture

Introduction

Current trends in information and communication technologies allow to create new business models with greater emphasis on human capital. New working environment modifies requirements for skills and education. According to the report of the Ministry of Education, Youth and Sports published in September 2012 (MEYS, 2012), the Czech tertiary education system offers within bachelor's and master's degree programmes over nine thousand field of studies. Most of them are offered in a full-time or a part-time mode of study, only four of them allow a distance mode of study. It means that although distance education has a long history, as a mode of study within a higher education is not currently usual in the Czech Republic.

This paper focuses on the field of study "Business Informatics" with distance mode of study which is offered within master's degree program at the University of Economics in Prague, Faculty of Informatics and Statistics. Its accreditation was the response to the growing demand from students. Students of informatics specialisations often start to work during their bachelor's degree and some of them leave the university after that. If their professional growth requires master's degree of study and they cannot leave their jobs, distance education happens to be a very convenient option for them.

Each field of study of any degree programme are subject to accreditation awarded by the Ministry of Education, Youth and Sports. The Accreditation Commission determines whether submitted field of study meets all requirements before the approval. The accreditation process is periodically repeated. Implementation of distance education had to be therefore very carefully monitored and its quality continually evaluated during the entire period of its accreditation. Jung et al (2011, p. 80) argues that "with the convergence of conventional and distance educational methods, there should be no distinctions between quality assurance in distance education and conventional education or between e-learning and face-to-face teaching".

Distance education has experienced dramatic growth since the early 1980s and has many definitions. The most often is cited Holmberg's (1986) definition from his book titled "Growth and Structure of Distance Education":

"Distance education includes the various forms of study at all levels which are not under the continuous immediate supervision of tutors present with their students in lecture rooms or on the same premises, but which, nevertheless, benefit from the planning, guidance and tuition of a tutorial organization."

Various forms of study, mentioned in the definition, also mean different methods of learning. Used methods changed from early correspondence courses, using primarily print-based materials, to courses with interactive materials accessible via information systems and information and communication technologies. New methods are based on Internet and multimedia technologies which make learning more attractive.

Online learning, which is a part of distance education, was the subject of many research studies. The Center for Technology in Learning performed (2010) a meta-analysis of the research literature from 1996 through July 2008 containing more than thousand empirical studies of online learning. The meta-analysis compared results of reviewed studies in differences between online and a face-to-face learning, in measuring of students' learning outcomes and in using of rigorous research design. One of the key findings was that "students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction" (p. xiv), combination of online and a face-to-face learning brought the best results. These positive results correspond to growing

trends in supporting face-to-face education by online learning and in implementation of distance education.

Carnwell (2000) investigated relationships among approaches to study, learning styles and materials design and how these approaches impacted students' need in a distance learning support. He argues that study material design influences the guidance and the support required by students. It is confirmed by Murphy and Rodríguez-Manzanares (2008), who found that an absence of body language and visual presence of teacher require to find new ways of interacting. This information corresponds to results of study (Houška, 2011), that the output knowledge of distance students without a special study material is worse than students who attended lectures. Therefore it is not surprising that interactive elements are necessary condition of well-prepared distance study material which is submitted to the Accreditation Commission.

This paper builds on the work of the author which was published as a contribution of the conference ERIE 2012 (Kunstová, 2012). The contribution was focused on interactive elements of e-learning materials. It contained analyses of using these interactive elements during winter semester 2011. This paper is extended by a data analysis from the next period (summer semester 2012) and by a comparison of results in both monitored periods. Data were obtained from the Integrated Study Information System. Because the first students were admitted in September 2011, data only from two periods are available. Although data sample is small, the results are very important for a managing of further distance education.

Materials and Methods

The comparability of distance and full-time education is based on the criteria that students' output knowledge has to be the same whether a course is taken online or face-to-face. Distance education is supported by e-learning tools. Typical e-learning courses define the procedure of teaching. These courses are prepared as a sequence of steps with checkpoints. The aim of checkpoints is to verify whether the student understood the issue and based on it let him move to the next step, or turn him back or recommend him a further study.

The field of study "Business Informatics" with the distance mode of study, which courses are analysed in this paper, is based on combination of regular meetings and e-learning study materials. This field of study does not have its alternative in full-time study, but its curriculum includes courses which are offered within other three fields of study of full-time study mode. The curriculum sets following eight mandatory courses in the first year of study:

- Course A – Information Management,
- Course B – Integration in Information Systems,
- Course C – IT Management,
- Course D – Text Information Processing Methods and Tools,
- Course E – Information Systems Audit,
- Course F – IS/ICT Project Management,
- Course G – Knowledge Discovery in Databases.
- Course H – Business Process Improvement.

E-learning study materials for these courses were created within e-Learning project functionality of the Integrated Study Information System. Each course has its own study material

that contains both passive (for example texts, presentations, lists of practice exercises, videos) and active (for example quizzes, on-line revision test) learning part. It is a comprehensive information source with a uniform basic structure for each course.

Because a direct teaching is replaced by the study material, it has to be prepared in a manner that leads students to think about explained issues. The study material for distance learning is not a textbook but rather a study guide. The study material has to keep students' attention and provide them continuous feedback, whether they understood the subject well. The study materials are divided into logical units either in accordance with the nature of the subject, or in accordance with the number of tutorials. Study materials have multi-level hierarchical structure, and create a crucial part of the support. They contain annotated interpretation issues, which are realized as a reference to the chapter in the literature, presentations, videos, case studies, assignments for independent work, control issues, etc.

The aim of my analysis was to evaluate the comparability of students' study results with full-time mode of study and analyse an early termination of the study and a usage of interactive elements within study materials.

This analysis attempts to answer the following research questions:

1. Does the early termination of study related to factors such as student's age, attended school, success at the entrance test?
2. To what extent students utilized online tests and lists of control questions?
3. How important were video records of lectures for students?

Most research studies are based on a retrospective evaluation by students and teachers, for example Vostrá Vydrová, H. et al (2012), Šírová E. and Krejčová K. (2011). Analyses, published in this paper, eliminate any subjective evaluation. Analysed data were obtained from several reports of the Integrated Study Information System and the MediaSite tool with video records. Data were obtained in the form of Excel tables from reports of admission procedure, examination reports and lists of statistics about accesses of students to each study material. Information about using of video records was transcribed from statistical reports of the MediaSite tool. Given the small sample of data only simple statistical calculations could be carried out. They were performed in Microsoft Excel software.

Results

Basis for knowledge comparability

Knowledge comparability is based on the fact that courses in distance as well as full-time mode of study have identical input assumptions, required and recommended lists of literature, PowerPoint presentations of the topics, requirements for individual work (case studies, essays, knowledge tests) and the final exam. Courses with distance form of study have thirteen weeks of lectures and seminars of full-time mode replaced by three tutorials and the special study material. On the other hand, due to their employment distance students are equipped with a practical experience to help them to understand new information faster and easier. Teachers at the final exam do not distinguish the mode in which the student attended the course. This comparability of output knowledge is evident, if the final exam is in the form of a written knowledge test.

All mentioned assumptions were met at all courses, which were held in the first academic year 2011/2012, therefore we can compare students' output knowledge on the basis of the final classification grade. The final classification includes evaluation of requirements fulfilment and a final knowledge examination. Results of this analysis are in Table 1.

		Full-time mode of study		Distance mode of study		
		Number of students	Average final classification	Number of students	Average final classification	Differences
Winter semester	Course A	46	2.43	17	2.41	0.02
	Course B	137	2.43	18	2.11	0.32
	Course C	73	2.00	19	2.11	-0.11
	Course D	21	2.48	19	2.32	0.16
Summer semester	Course E	16	1.75	14	2.43	-0.68
	Course F	58	2.48	17	2.35	0.13
	Course G	22	1.82	17	2.00	-0.18
	Course H	27	2.26	16	1.88	0.38

Table 1: Comparison of the average final classification

The data sample was cleaned before calculating the average classification grade. Data records of students without the grade were excluded from the file therefore student numbers in Table 1 include only students with final classification 1, 2, 3 or 4. It is pleasing, that comparable results were achieved.

From data in table 1 is seen, that only one course of distance students has significantly worse average final classification. On the other hand, this course has among full-time mode of study courses the smallest number of students. Final classifications are comparable for both modes of study.

Early termination of the study

Students with distance mode of study discontinue the study more often than students with full-time mode of study. Many students are not able to complete their courses because distance education requires self-discipline. Nobody pushes them to study continuously.

Success rate after two semesters of study is shown on Figure 1. From 25 students of distance mode of study, which were admitted to the study in the academic year 2011/2012, eight students terminated the study after the second semester. Positive values on the Y axis represent the successful completion of the semester (in this case the second one). Negative values on the Y axis mean the semester of termination. The size of circles corresponds to the number of students with a relevant birth year.

Four of the eight students, who terminated the study, graduate the bachelor's study at the Faculty of informatics and statistics, the rest of them were from other universities. Less successful are students who graduated two and more years before. No relationship to the order based on points from the admission test was detected.

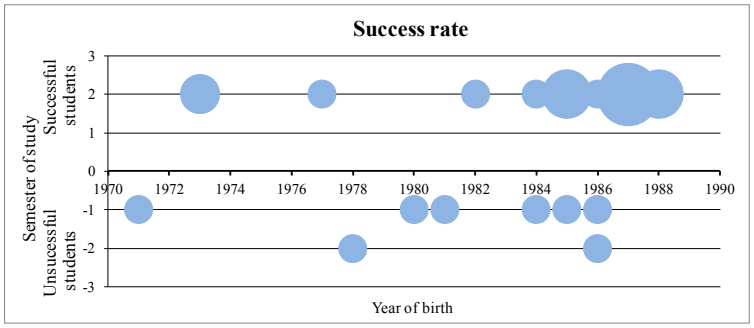

Figure 1: Success rate in view to the year of birthday

Accessing to online tests and lists of control questions

The second research target was to analyse access rate to online tests, which are available to students with distance mode of study in the e-learning materials. Online tests are interactive elements which aim is to give a feedback to self-study of students. Every test contains different number of questions. Questions are generated from the pre-prepared pool of test questions. Online tests could be repeated without limitations. Student always receives a new variant of the test. Test is evaluated immediately after its submitting. The test evaluation is not recorded, and teachers are not acquainted with it.

The Integrated Study Information System records date and time of all accesses to the e-learning material and its parts. These data are presented in several different outputs, usually shown per student. Available data, which have a different form (graph, table and list) and a level of detail, are accessible only to teachers of the courses and to administrator. From records about each student and the e-learning material for the each course was possible to obtain needed data for analyses. Available data do not contain a length of communication, only date and time when student clicked on an activity. A comparison of learning length would be very difficult even if the date of opening and closing activity would be available. The time spent over the opened activity is influenced by many factors. Also time, during which the student had the activity opened, does not mean that he was engaged in it.

Although basic structure of the e-learning materials is similar, the number of online tests is different. The number of accesses to online tests is showed in Figure 2. The Figure includes only five courses, because the remaining three courses have a very different number of online tests (one, five and seven) and the figure would be confusing. However, from the all data follows that the most often was opened the first test, then the opening of next tests is decreasing during the semester. The number of students, who never opened the tests during the semester, is increasing. Their number is growing average from three to eleven students. It is important to note that the correlation between the final classification and the using of the online tests did not occur.

Other element of a self-study providing feedback to students is a list of control questions. E-learning materials include the list of such questions at the end of each study unit. Questions are used to summarize the subject matter, to prepare for the tutorial and the final exam. The courses contain different numbers of the lists with control questions. Number ranges from one to seven lists. The frequency of accesses to the lists of questions is decreasing during the semester. One or two students, who did not display any list of questions, were in each course. The students were different. The correlation between the final classification and the using of the control lists of questions did not occur.

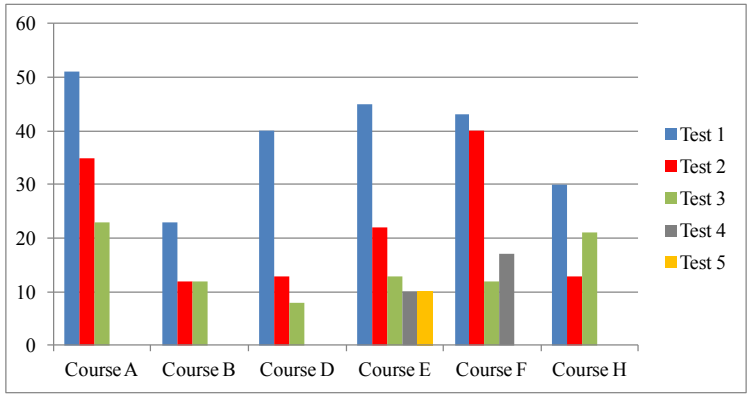

Figure 2: Number of accesses to online tests

Accessing to videos of lectures

The third part of the research should answer the question, how important were video records of lectures for students. The videos of lectures were taken in the previous academic year. Not all lecturers agreed with the acquisition of videos, therefore videos were available only for four of eight monitored courses. Three of them were prepared for courses in the winter semester, one of them was for a course in the summer semester.

Videos weren't accessible for students with full-time mode of study. The number of videos per course was from nine to twelve (see Table 2). Each video contains a PowerPoint presentation. The course C has doubled the number of lectures against the previous two, therefore duration of all videos is longer and the number of slides is greater. Large number of slides in the course F is caused by two video records with enormous number of slides (over three hundreds) which contain examples from case studies.

		Number of videos	Duration of all videos (minutes)	Number of slides	Total Number of accesses	Total number of watching students	Total time Watched (hours)
Course A		12	746	400	491	169	661
Course B		11	982	761	264	110	700
Course C		12	1546	1177	360	119	743
Course F		9	742	2978	118	36	204
Averages per 1 video	Course A	62	33	41	14	55	
	Course B	89	69	24	10	64	
	Course C	129	98	30	10	62	
	Course F	82	331	13	4	23	

Table 2: Statistics on videos

The main advantage of the videos is that the students can determine day and time when they will watch the lectures. They can track the video faster than was made, move over the video or repeat it. The main disadvantage is that the students cannot communicate with the teacher.

Although distance students did not have lectures, watching videos was not for them so important, as we supposed. None of the students has watched or even opened all available videos for the particular course. Even two video records from course F were not watched at all.

Discussion

The low success rate of distance mode of study is presented for instance in Jarkovská et al (2011), only 75% students in their observed year progressed to the 2nd year of study in the regular way (i.e. without retaking or interrupting the studies etc.). The success rate was even lower in our case, only 68% students progressed to the 2nd year. Most of unsuccessful students terminated their study already after the first semester (75%).

Because data sample was small (25 students started the distance study in September 2011 and eight of them have ended their study after the second semester), deeper statistical analysis is not possible. Nevertheless, it seems that younger students are more successful.

Comparison of average final classification confirmed the comparability of output knowledge. Only one course of full-time students had significantly better average final classification against to distance students in similarly large group. The full-time mode of study in small group could bring, maybe, better final results, but it would be hardly generally acceptable from society economic point of view.

Higher frequency of accesses to the first test and the list of control questions can be interpreted either by repeating the first tests and list of questions in next months, or by changing learning needs. Because the number of students, who never opened next tests or lists of control questions during the semester, was increasing, the second interpretation is probably more correct.

Balogh et al published (2011) similar results of their analysis. This analysis of accesses to the interactive animations integrated into the e-learning course provided also answer that interactive elements are used by students, but their use is heterogeneous. If final knowledge of students in both forms of study is comparable, heterogeneous access to interactivity elements is not necessarily a negative phenomenon.

Based on frequency of utilizing video records of lectures it could be assumed that it is not the most important source of information from distance students' point of view. This form of compensation of direct teaching is probably sufficiently replaced by e-learning materials.

Conclusion

Distance education includes methods and technology which let to achieve graduation without daily presence at a school. Distance education should be understood as self-learning supported by special study materials and only six tutorial hours per course during one semester. This paper focuses on the comparability of the output knowledge of students with full-time and distance mode of education. This comparability is based on the fact that students of both forms of study perform the same tasks and tests during the semester and pass the final knowledge exam together.

Students with distance form of study have to be personally motivated to continuous preparation for tutorials and individual homework. Interactive elements within distance study materials create the pressure to continuous learning but also provide feedback to understanding of study topics. Distance students have an important advantage in their experiences from a practice.

The basic analysis confirmed that the output knowledge of students, with a different mode of study, is comparable. Elements of e-learning materials, such as online tests and lists of control questions, played an important role in students' preparation on the tutorials and the final exams. But usage of

interactive elements had a decreasing trend. Video analysis showed that their watching was a significantly lower than we expected. This trend had a similar development in all courses.

Dependence between the final classification and the frequency of approaches to online tests, control lists of questions or video records did not occur.

The use of selected elements of distance education will be monitored also in the next periods. Larger data sets from multiple periods will enable to perform more detailed analysis and to compare statistical data concerning same courses from several semesters.

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MULTIPLE CHOICE QUESTION TESTS FOR ENTRANCE EXAMINATIONS - A PROBABILISTIC APPROACH

Jindřich Klůfa, Nikola Kaspříková

University of Economics, Prague
jindrich.klufa@vse.cz

Abstract

In this paper we shall analyze multiple choice question tests for entrance examinations from probability point of view. Multiple choice question tests are used for example for entrance examinations at Prague University of Economics, we shall analyze these tests at the Faculty of Business Administration. We shall report on probability methods, which can be used for modelling of these tests. In this case model of binomial distribution can be used for answering the following questions (under assumption of random choice of answers): what is the probability, that the number of correct answers exceeds given number, what is expected number of correct answers, etc. Results of this analysis can be used for consideration of the appropriateness of these tests.

Key Words

Binomial distribution, entrance examinations, examples, multiple choice question tests, probability

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Introduction

Multiple choice question tests (test has n questions, each question has m answers) are widely used in testing knowledge of students. One of the advantages of such type of test is that the results can be evaluated quite easily even for large number of students. On the other hand, a student can obtain certain number of points in the test purely by guessing the correct answers and this fact should be considered in interpretation of test scores. This problem is addressed in education research – see Zhao (2005), Premadasa (1993) and Klufa (2012).

We shall assume that the test has n questions, each question has m answers (one answer is correct), the wrong answer is not penalized. Such multiple choice question tests are used for example for entrance examinations at Prague University of Economics – see Klufa (2011). We shall analyze these tests at the Faculty of Business Administration (the same tests are used at the Faculty of Finance and Accounting and at the Faculty of Informatics and Statistics). Relation between results of entrance examination test and study results is not addressed in this paper, such analysis is performed e. g. in Kubanova and Linda (2012)). Note that standard (no multiple choice questions) tests, in which the student has to devise the answer by himself, are used for checking knowledge of students in mathematics courses at University of Economics – for analysis of such tests see (Kasprikova, 2011), but for entrance examinations, multiple choice questions are preferred so that the results of tests can be obtained quickly and there is clearly no impact of any subjective factor in evaluation. We provide an answer to the following questions (under assumption of random choice of answers): what is probability that number of correct answers exceeds given number and what is expected number of correct answers, etc. We shall use results of this analysis for evaluation of the appropriateness of these tests.

Materials and Methods

From probability point of view a multiple choice test means: Let us consider n independent random trials (questions) having two possible outcomes, say "success" (correct answer) and "failure" (wrong answer) with probabilities p and $(1-p)$ respectively. Probability of correctly answered question p (under assumption that each of m answers in particular question has the same probability and just one answer is correct) is $p=1/m$.

Let us denote X as number of successes that occur in n independent random trials. X is a discrete random variable (number of successes can be $0, 1, 2, \ldots, n$) distributed according to the binomial law with parameters n and p. Probability that number of successes is k is (see e.g. Rao, 1973)

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}, \quad k=0,1,2, \ldots, n. \qquad (1)$$

The expected value and the variance (dispersion) of random variable X distributed according to the binomial law with parameters n and p is

$$E(X) = n\,p, \quad D(X) = n\,p\,(1-p) \qquad (2)$$

The distribution function of discrete random variable X, i.e. probability that random variable X does not exceed x, distributed according to the binomial law with parameters n and p is

$$F(x) = 0, x < 0, \qquad F(x) = \sum_{k=0}^{[x]} \binom{n}{k} p^k (1-p)^{n-k}, x \geq 0 \quad (3)$$

where *[x]* is integer part of *x*.

Results

Entrance examinations in mathematics

Entrance examinations in mathematics have 10 questions for 5 points and 5 questions for 10 points (100 points total). Questions are independent. Each question has 5 answers (one answer is correct), wrong answer is not penalized. Under assumption that each answer has the same probability, probability that a particular question is correctly answered is *p=1/5.*

Example 1. Under assumption of random choice of answers we shall find probability that number of points in the test in mathematics is 15.

Let us denote

Y = number of points in the test in mathematics

X_1 = number of correct answers in the first 10 issues

X_2 = number of correct answers in 10-points tasks

It holds

$$P(Y=15) = P[(X_1=1 \cap X_2=1) \cup (X_1=3 \cap X_2=0)] = P[(X_1=1 \cap X_2=1)] + P[(X_1=3 \cap X_2=0)]$$

Random variables X_1, X_2 are independent, therefore we have - see e.g. Rényi (1972)

$$P(Y=15) = P(X_1=1)\, P(X_2=1) + P(X_1=3)\, P(X_2=0)$$

Random variable X_1 has binomial distribution with parameters *n=10* and *p=0,2.* Random variable X_2 has binomial distribution with parameters *n=5* and *p=0,2.* According to (1) we obtain

$$P(Y=15) = \binom{10}{1} 0{,}2\ 0{,}8^9 \binom{5}{1} 0{,}2\ 0{,}8^4 + \binom{10}{3} 0{,}2^3\ 0{,}8^7 \binom{5}{0} 0{,}8^5 = 0{,}175922$$

Analogously, we can calculate the probability *P(Y=k)* for other *k=0, 5, 10, 15, ... , 95, 100* (see Table 1 and Figure 1). For this calculation we have used the Mathematica software (Statistics 'DiscreteDistributions') – see Wolfram (1996)

Points in the test	Probability	Points in the test	Probability
0	0,035184	55	0,002890
5	0,087961	60	0,000957
10	0,142937	65	0,000275
15	0,175922	70	0,000067
20	0,174547	75	0,000014
25	0,146098	80	0,000002
30	0,105227	85	3×10^{-7}
35	0,066057	90	2×10^{-8}
40	0,036467	95	1×10^{-9}
45	0,017761	100	3×10^{-11}
50	0,007634	Sum	1,000000

Table 1: Distribution of number of points in the test (mathematics)

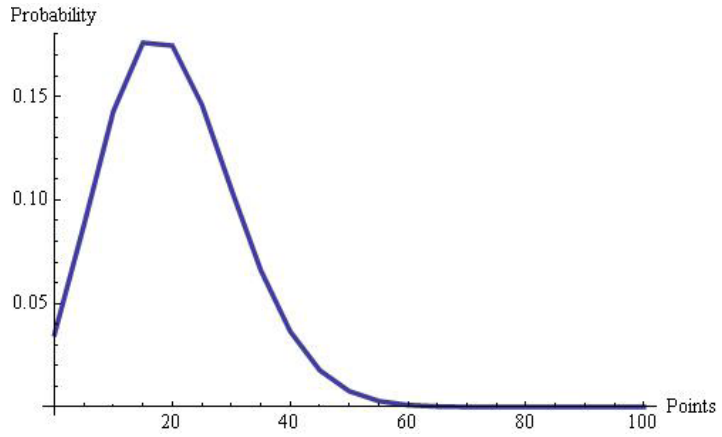

Figure 1: Distribution of number of points in the test (polygon) – mathematics

Example 2. Under assumption of random choice of answers we shall find probability that number of points in the test in mathematics is

(a) 30 and more,

(b) 40 and more,

(c) 50 and more.

(a) Using notation from example 1 we have - see e.g. Marek (2012)

$$P(Y \geq 30) = 1 - P(Y<30) = 1 - P[(Y=0) \cup (Y=5) \cup (Y=10) \cup (Y=15) \cup (Y=20) \cup (Y=25)] =$$

$$= 1 - [\, P(Y=0) + P(Y=5) + P(Y=10) + P(Y=15) + P(Y=20) + P(Y=25) \,]$$

Finally, from Tab.1 we obtain

$$P(Y \geq 30) = 1 - 0{,}762649 = 0{,}237351.$$

Under assumption of random choice of answers almost a quarter of students get the test score 30 or more points.

(b) Analogously, we obtain

$$P(Y \geq 40) = 1 - P(Y<40) =$$

$$= 1 - [\, P(Y=0) + P(Y=5) + P(Y=10) + P(Y=15) + P(Y=20) + P(Y=25) + P(Y=30) + P(Y=35) \,]$$

Finally, from Tab.1

$$P(Y \geq 40) = 1 - 0{,}933933 = 0{,}066067.$$

Under assumption of random choice of answers approximately 6,6% of students get the test score 40 or more points.

(c) Finally

$$P(Y \geq 50) = 1 - 0{,}988161 = 0{,}011839.$$

Under assumption of random choice of answers approximately 1,2% of students get the test score 50 or more points.

Example 3. Under assumption of random choice of answers we shall find the expected number of points in the test in mathematics and mode.

Using notation from example 1 we have

$$Y = 5\,X_1 + 10\,X_2$$

Therefore - see e.g. Feller (1970)

$$E(Y) = E(5X_1 + 10X_2) = 5\,E(X_1) + 10\,E(X_2)$$

According to (2) we obtain (e.g. $E(X_1) = 10 \,.\, 0{,}2 = 2$)

$$E(Y) = 5 \,.\, 2 + 10 \,.\, 1 = 20.$$

Expected number of points in the test is 20. The mode is the most probable number of points. From Tab.1 is

$$\hat{y} = 15.$$

Entrance examinations in English

Entrance examinations in English (or other language) have 50 questions for 2 points (100 points total). Questions are independent. Each question has 4 answers (one answer is correct), the wrong answer is not penalized. Under assumption that each answer has same probability, probability that a particular question is answered correctly is *p=1/4.*

Example 4. Under assumption of random choice of answers we shall find probability that number of points in the test in English is 20.

Let us denote

Z = number of points in the test in English

X = number of correct answers in the 50 issues

Random variable X has binomial distribution with parameters *n=50* and *p=0,25.* According to (1) we obtain

$$P(Z = 20) = P(X = 10) = \binom{50}{10} 0{,}25^{10}\, 0{,}75^{40} = 0{,}098518$$

Analogously, we can calculate the probability *P(Z=k)* for other *k=0, 2, 4, 6, 8, ... , 98, 100* - see Table 2 (only for *k=0, ... , 66,* other probabilities are less than 10^{-9}) and Figure 2. For this calculation we have used the Mathematica software (Statistics 'DiscreteDistributions') – see Wolfram (1996).

Points in the test	Probability	Points in the test	Probability
0	0,000001	36	0,026390
2	0,000009	38	0,014816
4	0,000077	40	0,007655
6	0,000411	42	0,003645
8	0,001610	44	0,001602
10	0,004938	46	0,000650
12	0,012345	48	0,000244
14	0,025865	50	0,000084
16	0,046341	52	0,000027
18	0,072087	54	0,000008
20	0,098518	56	0,000002
22	0,119416	58	0,000001
24	0,129368	60	1 x 10-7
26	0,126050	62	3 x 10-8
28	0,111044	64	6 x 10-9
30	0,088836	66	1 x 10-9
32	0,064776	***	***
34	0,043184	Sum	1,000000

Table 2: Distribution of number of points in the test (English)

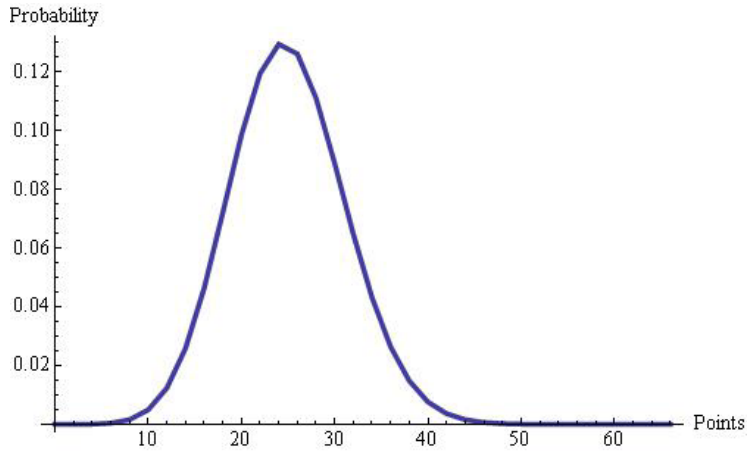

Figure 2: Distribution of number of points in the test (polygon) – English

Example 5. Under assumption of random choice of answers we shall find probability that number of points in the test in English is

(a) 30 and more,

(b) 40 and more,

(c) 50 and more.

(a) Using notation from example 4 we have

$$P(Z \geq 30) = 1 - P(Z<30) = = 1 - [\, P(Z=0) + P(Z=2) + P(Z=4) + \ldots + P(Z=26) + P(Z=28)\,]$$

Finally, from Tab.2 we obtain

$$P(Z \geq 30) = 1 - 0{,}748080 = 0{,}251920.$$

Under assumption of random choice of answers approximately quarter of students get the test score 30 or more points.

(b) Analogously, from Tab.2 we obtain

$$P(Z \geq 40) = 1 - P(Z<40) = 1 - 0{,}986082 = 0{,}013918.$$

Under assumption of random choice of answers approximately 1,4% of students get the test score 40 or more points.

(c) Finally

$$P(Z \geq 50) = 1 - 0{,}999878 = 0{,}000122.$$

Under assumption of random choice of answers approximately 0,01% of students get the test score 50 or more points.

Example 6. Under assumption of random choice of answers we shall find the expected number of points in the test in English and mode.

Using notation from example 4 we have $Z = 2\,X$. According to (2) we obtain

$$E(Z) = E(2X) = 2\,E(X) = \ 2\ .\ 12{,}5 = 25.$$

The expected number of points in the test in English is 25. The mode is the most probable number of points. From Tab.2 is

$$\hat{z} = 24.$$

Discussion

Real results of entrance examinations in 2012 are in Figure 3 (mathematics) and Figure 4 (English or other language). For example, a mean number of points in the test in mathematics is 64,7 (expected number of points in the test, under assumption of random choice of answers, is 20 - see results of Example 3). Similarly, a mean number of points in the test in English or

other language is 68,0 (expected number of points in the test, under assumption of random choice of answers, is 25 - see results of Example 6). The results obtained are valid under the assumption of random choice of answers (pure guessing). In such cases, each of *m* answers has the same probability and questions are independent.

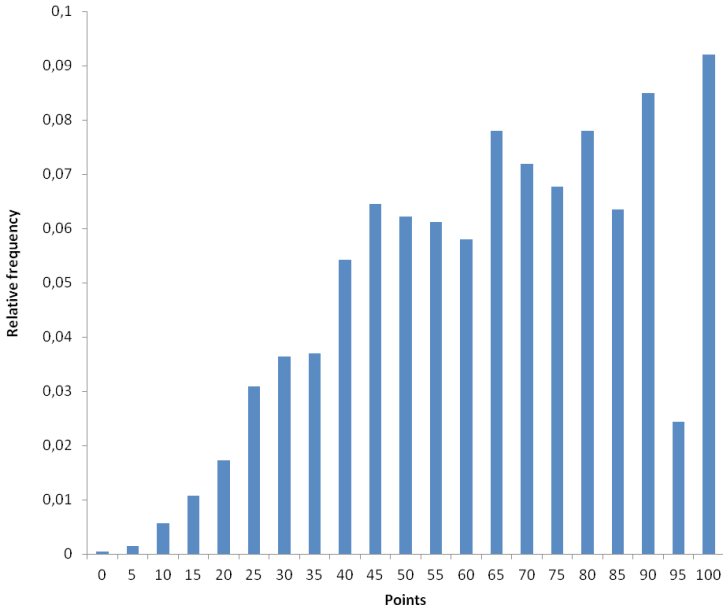

Figure 3: Real distribution of number of points in mathematics in 2012 (histogram)

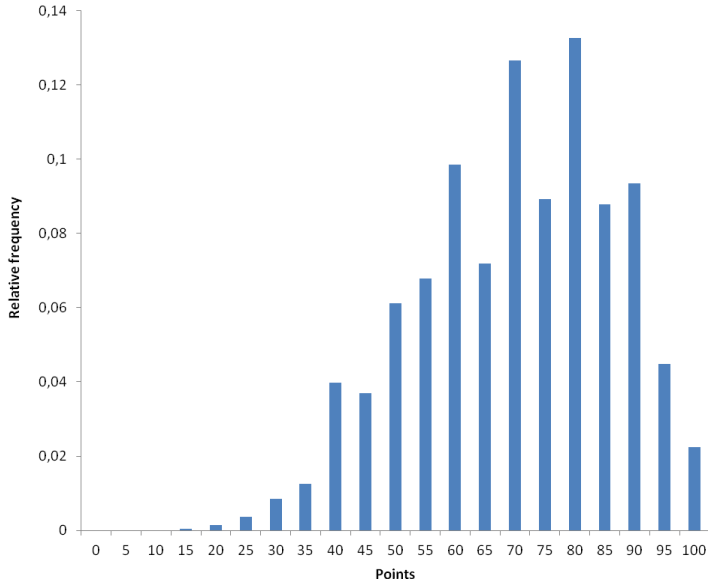

Figure 4: Real distribution of number of points in English or other language in 2012 (histogram)

Conclusion

Random variables Y (number of points in the test in mathematics) and Z (number of points in the test in English) are independent. Therefore, under the assumption of random choice of answers, probability that number of points in both tests (mathematics and English) is 50 and more is (see results of Example 2 and Example 5)

$$P(Y \geq 50)\ P(Z \geq 50) = 0{,}011839 \times 0{,}000122 = 0{,}000001.$$

It means that approximately one student in a million (without any knowledge) successfully passes the entrance examinations at University of Economics. Multiple choice question tests are suitable for entrance examinations at University of Economics. These tests are objective (there is clearly no impact of any subjective factor in evaluation). Moreover, results can be evaluated quite easily for large number of students. Results of this paper show that risk of success of students with lower performance levels is negligible.

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STATISTICAL EVALUATION OF EXAMINATION TESTS IN MATHEMATICS FOR ECONOMISTS

Nikola Kaspříková

University of Economics, Prague
nikola.kasprikova@vse.cz

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Abstract

Examination results are rather important for many students with regard to their future profession development. Results of exams should be carefully inspected by the teachers to help improve design and evaluation of tests and education process in general. Analysis of examination papers in mathematics taken by students of basic mathematics course at University of Economics in Prague is reported.

The first issue addressed is identification of significant dependencies between performance in particular problem areas covered in the test and also between particular items and total score in test or ability level as a latent trait. The assessment is first performed with Spearman correlation coefficient, items in the test are then evaluated within Item Response Theory framework. The second analytical task addressed is a search for groups of students who are similar with respect to performance in test. Cluster analysis is performed using partitioning around medoids method and final model selection is made according to average silhouette width. Results of clustering, which may be also considered in connection with setting of the minimum score for passing the exam, show that two groups of students can be identified. The group which may be called „well-performers“ is the more clearly defined one.

Key Words

Education research, examinations, IRT, mathematics for economists, segmentation

Introduction

A lot of data is quite naturally collected within process of teaching. It is not only data obtained by automated data registration related to usage of modern web-based e-learning systems, even though this is nowadays probably the most data-intensive area in education and also heavily utilised for analyses (for overview of data mining methods related to analysis of e-learning systems see e. g. Romero and Ventura (2007). Another (and more traditional) sources of data are sample surveys and data about examinations. A number of analyses are being performed and many descriptive or prediction models are built using data related to education process, see Kotsiantis, Pierrakeas and Pintelas (2004) for details.

Evaluation of performance of students is an important part of education process and it may also provide useful information for assessment of the effects of education process and results of an analysis may suggest how to improve the teaching process. Data about tests represent valuable source of information if used for further analysis.

Data analysis can provide answers to questions such as:

1. Are there any dependencies between performance in test and other, e.g. behavioural or demographic characteristics of students?
2. What are the dependencies between performance in particular problem areas covered in the test and what are the relations of items to total score or even to assumed latent ability trait?
3. Are there any groups of students who are similar with respect to performance in test?

Analytical question (1) is rather basic one and may easily be answered using standard statistical framework of hypothesis testing. Evaluation of performance in basic mathematics course with respect to gender and major field of study is discussed in (Kaspříková, 2012).

Analysis of relations between particular problem areas covered in test and correlation of items with total test score was discussed in (Kaspříková, 2011) and the analysis is further extended in this paper to cover characteristics of items with respect to assumed ability level.

Analytical task (3) may be solved using clustering methods and the results may be used e.g. for setting optimal cut-off points for passing the exam (see Sireci and Robin (1999)).

This paper addresses just subset of possible analytical questions. Many other questions may arise within the scope of analysis of exams, such as a search for common factors influencing performance in tests - there is usually a general factor which may be interpreted as general ability to solve tasks. Another common analytical task is examination of reliability of tests and analysis of sources of variability, including investigation of effect of examiners - see Cronbach (2004), Holland and Hoskens (2003) and Harik et al. (2009).

This paper shows application of both basic data analysis techniques and more advanced data mining tools for analysis of tests taken by students of basic "all-in-one" mathematics course at University of Economics in Prague, with the aim to get answers to the questions (2) and (3) stated above. We will investigate if there are some significant dependencies between test items and total score or ability level. Then a cluster analysis will be performed to learn if there are some groups of students homogeneous with respect to performance in test and if so, what is the most suitable value for cut-off point for passing the exam.

Materials and Methods

Data description

Sample of N=45 test papers in mathematics is available for analysis. For all the tests the following structure holds: there are 8 tasks in test, covering the topics of basic lectures of mathematics for economists. Tests included namely one item which can be classified as basic linear algebra calculations (henceforward denoted LA), then matrix algebra task (denoted MA), limit calculation (LF), item focused on rather straightforward derivatives application (D1), item including a more difficult application of derivatives (D2), integral calculation (IN), optimization of a function of two variables (F2) and solving a differential equation (DE). If an item was perfectly solved by the student, it was evaluated by 5 points, otherwise an evaluation between 0 and 5 points could by assigned for a partially correct solution. Following the evaluation of particular items, an overall score (denoted SC) was calculated as sum of all eight evaluations for particular test items, i.e. SC = LA + MA + LF + D1 + D2+ IN + F2 + DE, thus giving nine variables for analysis in all.

Basic univariate analysis, data preparation and statistical methods

Basic univariate sample statistical summary characteristics of variables investigated are given in Table 1.

	LA	MA	LF	D1	D2	F2	IN	DE	SC
Min	0	0	0	0	0	0	0	0	0
Median	5	5	5	5	3	2	3	2.5	27
Mean	3.9	3.8	3.5	3.5	2.8	2.4	2.7	2.6	25.3
Max	5	5	5	5	5	5	5	5	40

Table 1: Basic sample summary statistics

The distribution of score assigned for particular items and total score is illustrated in Figure 1.

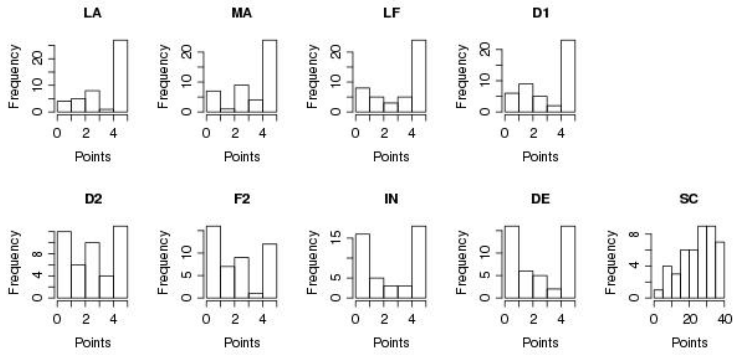

Figure 1: Histograms of scores for particular test items and overall test score

Based on histograms it can be observed that obviously the variables do not follow normal distribution and indeed with formal tests of normality based on sample kurtosis and sample skewness, except for D1, D2, F2 and SC variable the null hypothesis is rejected at 0.05 significance level. It is more often the case that a student either solves the task completely (and obtains 5 points for the item) or gets 0 score for the item, than it is the case that there is a partial solution of the task.

Non-normality of variables to some extent limits the range of statistical methods applicable to this data.

For general multivariate analysis of dependencies between overall score and particular problem areas covered in test we first perform simple bivariate analysis. Dependency between every two variables is assessed with Spearman correlation coefficient, i.e. the analysis is actually based on ranks of original variables. We are considering multiple evaluations (there are 9*8/2=36 pairs of variables) in the analysis and significance level of 0.001 is used for assessment of statistical significance.

For data analysis within item response theory (IRT) framework we convert each variable to binary using value 3 as cut-off point – assigning value 1 if the original value is at least 3 points and assigning 0 otherwise. This way of recoding is supported by rather high frequencies of 0 and 5 points (see histograms in Figure 1) and provides us with dichotomous variables which have clear interpretation – we get 1 if the performance of the student in particular item was "good" and we get 0 if the performance was "bad". Such simplified classification, if applied directly when evaluating the tests, could be also easier for the teacher in comparison with assigning 0 to 5 points for every task. We use two-parameter logistic model described and implemented by Rizopoulos (2006). In this model, probability of correct answer in particular item i by the student is given by the ability level of the student and by item characteristics. It holds

$$\log\left(\frac{p_i}{1-p_i}\right) = a_i + z_m b_i$$

where

p_i is probability of correct answer in particular item i by the student,

a_i is the easiness parameter of the item,

b_i is discrimination parameter of the item (showing how well the item discriminates between students with low and high level of latent ability trait),

z_m is ability level of the student.

Answer in particular item is manifest variable and ability level is latent variable in this model and values of variable are estimated for every student. The model which we have chosen allows that items may be different with respect to their difficulty and discrimination power. We do not use three parameter model with guessing parameter, because the tasks in the test can not be solved by pure guessing. Item characteristic curve and item information curve (see Rizopoulos (2006)) for particular items will be evaluated in the analysis. Item characteristic curve (ICC) shows probability of correct answer as a function of ability level and item information curve (IIC) can be used for assessment of how much useful the item in test is for various levels of ability trait.

Cluster analysis is performed using partitioning around medoids method, implemented in cluster package in R computing environment (for detailed description of the method see Struyf, Hubert and Rousseeuw (1997)). Partitioning around medoids has a couple of advantageous properties, one of them is no need for initial guess of the cluster centres. Another property which makes this method suitable to be used in our analysis is that it works with medoids, which are real representatives, as opposed to centres (used e.g. in standard k-means clustering), which may often be artificial. Silhouette width, described by Rousseeuw (1987), is used for formal evaluation of quality of clustering model and for model selection.

R environment for statistical computing (Hornik and Leisch (2004) and R Development Core Team (2012)) is used for the calculations.

Regarding elementary characteristics of the test, Cronbach's alpha, commonly used for assessment of reliability, is 0.81; difficulty of the test is 0.61 and discrimination value is 0.63.

Results

Correlation analysis

Dependencies between items and overall score are depicted in Figure 2. There is an edge between two nodes if the null hypothesis of zero correlation coefficient has been rejected. Edges in the graph are then evaluated with sample Spearman correlation coefficient.

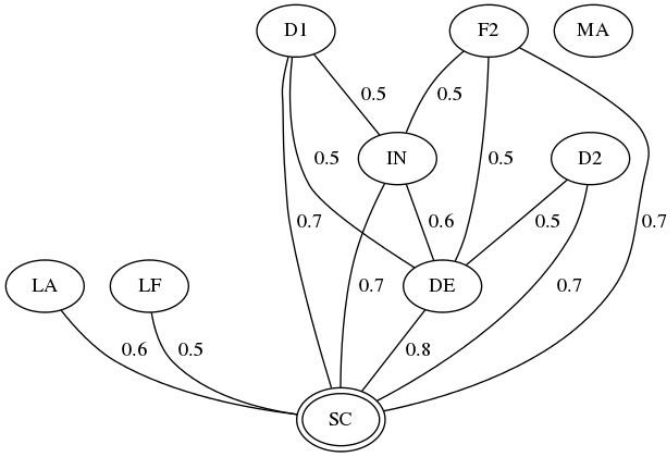

Figure 2: Dependency graph for test scores with Spearman correlation coefficient

IRT analysis

Results obtained for particular items using two-parameter logistic IRT model are shown in Figure 3 and Figure 4, which show item characteristic curves and item information curves respectively. Three-parameter logistic IRT model has also been fitted, but it did not bring better fit compared with the two-parameter model at 0.05 significance level so it is not further reported here.

Cluster analysis

Two groups of students were identified in cluster analysis of data about performance in test. Number of clusters was selected according to the highest average silhouette width. Number of students included in particular clusters was 25 for Group 1 and 20 for Group 2 respectively. For basic characteristics of the resulting clusters see Table 2. Average silhouette width of the resulting clustering model is 0.26.

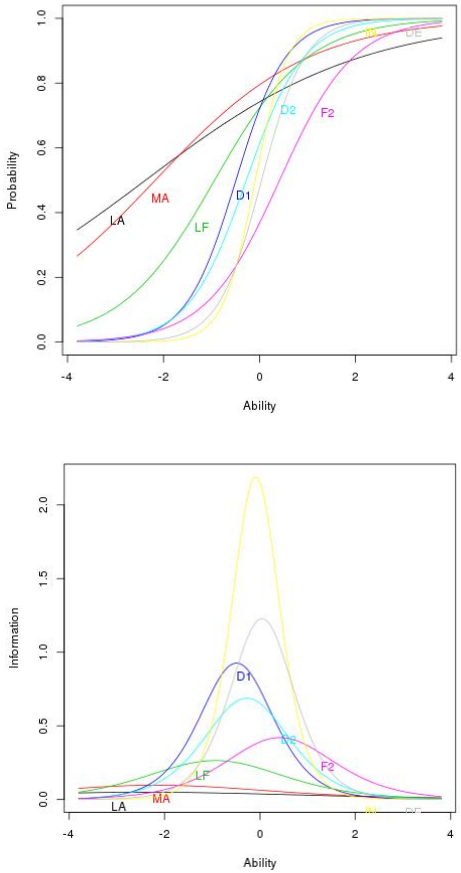

Figure 3 and 4: Item characteristics curves and Item information curves

	Number of students	Mean score in test	Average silhouette width
Group 1	25	18.4	0.14
Group 2	20	33.8	0.4

Table 2: Profiles of groups resulting from cluster analysis

Average total score SC (this variable was not included as input variable to clustering algorithm) in Group 1 is considerably lower (18.4) than in Group 2 (33.8). Density estimates of total score by cluster are illustrated in Figure 5. Average score for every particular test item was higher for Group 2 than for Group 1, so Group 2 can be called "well-performers". The cut-off value for total score to distinguish between clusters is at some 26 points, which represents 58 % of score which can be reached in the test.

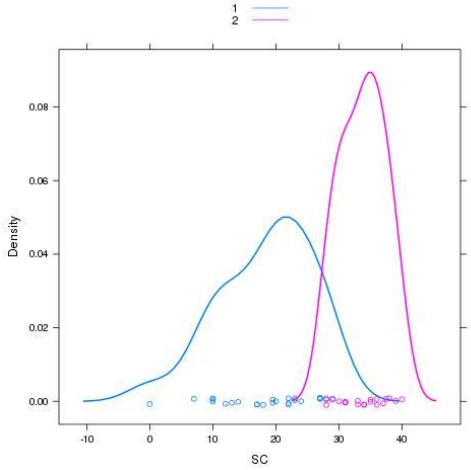

Figure 5: Density estimates of score by cluster, Group 2 on the right-hand side

Discussion

All the dependencies shown in Figure 2 are positive, i.e. with positive correlation coefficient. This is in agreement with our expectation and may be a demonstration of a general ability concept referred to in other analyses and captured formally in IRT theory (Sheng and Wikle 2008), as if a student performs well in one part of mathematics, it is likely that performance in solving problems related to another part of mathematics will be good as well.

Clearly (and as could have been expected) SC represents the node with highest degree (7 connections) in the graph in Figure 2, followed by DE (5 connections) and IN (4 connections). On the other hand, matrix algebra task seems to be rather independent of other items in test and even of overall score. LA and LF are dependent just on overall score.

The highest dependency, according to the correlation coefficient value, was observed between overall score and a test item focused on differential equations. Rather high correlation was observed between overall score and D2, D1, F2, IN. High correlation is also between DE and D1.

Evaluation of items in the test within the IRT framework shows that F2 task may be considered as rather difficult one (see ICC curves in Figure 3). According to item information curves (see Figure 4) it seems that most items in the test are most useful for assessment of students with medium level of ability. F2 task may be useful for evaluation of students with higher ability level, performance in MA and LA tasks does not seem to reflect ability level well and perhaps these tasks should be removed from the test. IN or DE task may be used for quick assessment of students with medium ability level. In case that there was a need to better distinguish ability of students with rather high ability level or similarly for increasing information value of the test on ability levels of low ability students, the test would have to be redesigned. But taking into consideration the fact that the test is designed for a course in basic mathematics for students whose major field of study is economics, it may be appropriate that the test is calibrated for medium ability level students.

Regarding cluster analysis results, average silhouette width of the resulting clustering model is 0.26. This value suggests that assumption about existence of the clustering structure in the data is not groundless, even though the classification structure is not very strong.

Average silhouette width was higher in Group 2 (0.4) than in Group 1 (0.14), suggesting that Group 2 represents the more clearly defined group.

The cut-off value discovered in cluster analysis is quite close to the value which is usually set for passing the exam (60%), so the analysis has confirmed that the 60% cut-off is not set at some groundless level and that such value is based on some sort of a natural split. Note that the cut-off value for passing the exam should be communicated to students in advance, so there is definitely a need for some sufficiently stable cut-off value. It may not be a good idea to use different cut-off values based on every particular test, even though such cut-off values may have better characteristics form analytical point of view.

Results of cluster analysis can be compared with clustering of another, larger sample of 110 tests, described in (Kaspříková, 2012) and coming from another academic period, after slight changes in curriculum of the course. The test consisted of two parts. The first part (mid-term test) covered topics in linear algebra and introductory topics from mathematical analysis (limit calculation and derivatives). The second part (final test) was taken by students at the end of the term and this part

covered topics of mid-term test and a couple of other topics form mathematical analysis, namely integral calculation, optimization task and a differential equation. There was not any requirement regarding limit for minimal number of points obtained in the first test to be entitled to take the second part of the test and all students have taken both parts of the test. The best clustering model reached average silhouette width 0.6 and it was again a two clusters solution, in which the group with higher mean score was the more clearly defined one. This may be considered as some sort of validation of results described in this paper and it suggests that the obtained clustering structure may hold over time.

Conclusion

It was shown that statistical analysis of examination papers can provide insights into structure of students' performance and it can also provide some assessment regarding design of the test. Results of our analysis addressing tests in basic mathematics for economists course suggest that for a quick assessment of student performance in the course just subset of tasks in test could be used, focusing mostly on comparatively advanced parts of the course, which are differential equations or integral calculation and optimization of functions of two variables. Also a finding of no strong dependence of performance in matrix algebra task (both on performance in other items and on assumed latent ability trait) is interesting and may lead to considerations resulting in removing this task from the test. But these results should be validated in future research after collecting larger data sample. Evaluation using two-parameter logistic IRT model has shown that optimization of functions of two variables may be considered as rather difficult task in the test and that the tasks in the test are mostly useful for assessment of performance of students with medium ability level.

Results of cluster analysis suggest that two groups of students, covering approximately 60% and 40% of students and with different level of performance in test can be identified. The smaller group, which may be called "well-performers", seems to be the more clearly defined one. The suggested cut-off value is approximately 58% points, which is close to the usually used value, which is 60%.

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ADAPTIVE E-LEARNING AND ITS EVALUATION

Kateřina Kostolányová, Jana Šarmanová, Ondřej Takács
University of Ostrava
katerina.kostolanyova@osu.cz

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Abstract

This paper introduces a complex plan for a complete system of individualized electronic instruction. The core of the system is a computer program to control teaching, the so called "virtual teacher". The virtual teacher automatically adapts to individual student's characteristics and their learning style. It adapts to static as well as to dynamic characteristics of the student. To manage all this it needs a database of various styles and forms of teaching as well as a sufficient amount of information about the learning style, type of memory and other characteristics of the student. The information about these characteristics, the structure of data storage and its use by the virtual teacher are also part of this paper.

We also outline a methodology of adaptive study materials. We define basic rules and forms to create adaptive study materials. This adaptive e-learning system was pilot tested in learning of more than 50 students. These students filled in a learning style questionnaire at the beginning of the study and they had the option to fill in an adaptive evaluation questionnaire at the end of the study. Results of these questionnaires were analyzed. Several conclusions were concluded from this analysis to alter the methodology of adaptive study materials.

Key Words

e-learning, adaptability, adaptive learning environment, individualized instruction, learning style, evaluation, analysis

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Introduction

Individualized instruction is nothing new in the field of education. This approach has been recommended in the form of a principle since the age of J. A. Komenský. The key point of individualized approach is the students themselves, studying. Each is an individual from many points of view:

- their talent differs in different fields of study,
- their entry knowledge of the subject they currently study can differ,
- they prefer different learning style than others,
- they can have different type of memory,
- their memory is better trained than the memory of others,
- they can have different motivation to learn, different family background, different study habits.

The ideal teacher is able to adapt to the needs of the student. They know the preferences of the student and their permanent characteristics. They are also able to recognize student's current shortage of knowledge and adapt the speed and style of teaching appropriately. Taking all this into consideration can produce an optimal teaching instruction.

During self-study, students usually use textbooks. A good textbook can be understood as a different form of teacher. The author puts in their optimal teaching instruction, their scope and detail of presented information.

It is necessary to create a teaching system that will take student's preferences and the absence of "live" teacher into account when presenting new information. To choose a suitable learning style for a student you need to know their characteristics.

Principle of Making Adaptive Environment

Nowadays, LMS systems are used to store study materials, control instruction, register students, record students' activities and their results. However, LMS systems do not take learning styles into consideration.

A global approach to deliver schoolwork to students is provided regardless of their learning styles and levels of knowledge [Brusilovsky, 1998; Brusilovsky, 2001]. If the student is not participating in face to face communication with the teacher, they use textbooks to study. Authors usually use global approach to structure topics in the textbooks, not taking learning styles into consideration [Kulič, 1980].

The electronic adaptive environment, however, follows the behavior and characteristics of a particular student. Before the student starts their study of a particular subject, they fill in a questionnaire to find out their preferences in various areas of study:

- sensory perception,
- social aspects,
- emotional aspects,
- learning tactics: ability to be systematic, study approach, study methods and self-regulation.

Study material is prepared for particular users in relation to their abilities, preferences and needs, taking learning styles into consideration. To respect differences among its users, the system cannot be anonymous. Data collection of student's information is done in several steps.

The most important step is the evaluation of the student. It means that the student will be tested before entering the course (test results will be classified as "constant parameters") and

during the course (test results will be classified as "dynamic parameters"). These dynamic parameters are used to modify the course path.

The objective of adaptive instruction is not only to adapt the instruction to student's needs. In case the student has satisfying study habits, there is no need to direct their effort. It would be more effective to offer different methods and learning styles to them that they might find interesting and that would be more effective for their study than those they have used so far. On the contrary, there are students who do not have satisfactory study habits. Their study is superficial without understanding the essence of the lesson and they do not have the ability to put what they have learnt into practice. In this case, the task of adaptive algorithms is to teach these students a better learning style.

Adaptive Systems

"A learning environment is considered adaptive if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process" [Paramythis, 2003].

Adaptive learning can have many forms that can be divided to following categories (Paramythis, 2003): adaptive interaction, adaptation of content, content discovery and assembly, and adaptive collaboration support.

The first category, Adaptive Interaction, adapts the user interface of the learning environment, such as colour schemes, fonts, etc. together with the structure of the user interface and the order of system's actions.

The second category, Adaptive of Content, changes the structure and presentation of the course in a way, that suites user's characteristics and optimizes quality and time of learning. This way of adaptation involves dynamical changes in the navigation elements of the course and its structure and dynamical selection of its suitable parts.

The third category, Content Discovery and Assembly, selects the most beneficial learning material from potentially distributed sources on the basis of users known characteristic and goals.

The fourth and final category, Adaptive Collaboration Support, is focused on the communication between multiple persons and on different kinds of user collaboration. Adaptive techniques can be used to facilitate the communication and collaboration, ensure a good match between users, etc.

This paper is focused on the Adaptive of Content.

Systems that Adapts the Content

There already exists some systems that adapts the content to each individual student. But they are too limited.

System AHA! (Adaptive Hypermedia for All) [De Bra, 2003] can adapt the contentent, but it is very hard to do, because each author has to design everything: what properties he will measure, how he will measure it, what changes in the content he will do to each set of properties.

System PEL-IRT (Personalized E-Learning system based on Item Response Theory) [Chih-Ming 2005] and Feijoo.net [Kalyuga, 2005] adapts content in too big parts and is limited to only two properties of students.

Research of Adaptation of Content

This paper is focused on the adaptation of learning content and describes how exactly it is done. Research in this area is a long term process, because there are many stages that must be finished before the research can start. The adaptive learning system must be designed and implemented first, so there is some environment to do research in. After this, group of authors must design and create the content of the system: adaptive teaching support. When these tasks are finished, students can begin the studying in this adaptive system, we can measure their progress and make some conclusions.

Objective of this paper is to describe the prototype of adaptive system, adaptive teaching system and the results of preliminary research. The hypotheses of our research are:

1. Students gain more knowledge and skills when they learn from adaptive teaching supports than if they learn from common textbooks.
2. Students are more motivated to learn from adaptive teaching supports than from common textbooks.
3. Students are learning more quickly from adaptive teaching supports than from common textbooks.
4. Students can learn to learn more from adaptive teaching supports than from common textbooks.

In this early stage we use only simple questionnaire survey as research method to get some early feedback, so only first two hypotheses were considered.

Materials and Methods

Design of Adaptive LMS Structure

Electronic adaptive environment consists of three modules – student's module, author's module and adaptive module (figure 1).

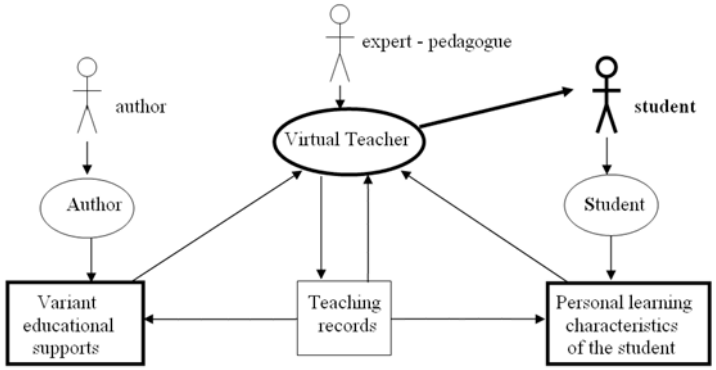

Figure 1: Model of adaptive learning environment

Student's module

In this module, student plays the key role. From all the characteristics of the student we should pay the most attention to their learning style. Nowadays, many classifications of learning styles exist. For this reason, the following characteristics to be used in e-learning has been chosen [Kostolányová, 2010; Kostolányová, 2011b].

The chosen characteristics were classified into these categories:

1) *sensory perception* describes the preferred form of information delivery to the student. Visual type of student prefers schemes, pictures, tables and graphs. Auditory type of student prefers spoken language and contact with other people. Kinesthetic type of a student prefers demonstration, models and practical information. Verbal type of student prefers information in a text form.

2) *social aspects* deal with the most convenient study environment for the student. Do they like to study with other schoolmates? Do they like to study with the help of the teacher? Do they prefer to study individually?

3) *emotional aspects* deal with feelings and attitudes of student that influence the process of learning. The most important characteristic from this category is motivation of which two parts can be observed – external and internal. While external conditions such as job or family requirements are the source of external motivation, the source of internal motivation is the student her/himself.

4) *learning tactics* describe the "methods" of how students study. Ability to be systematic describes how the student studies. Do they study step by step according to the instructions (pole: order) or do they study in a random order (pole: free hand)?

5) *study approach* can be divided into two groups. In the first group there are tactics including theoretical deduction. Students who prefer these tactics like to focus on details. In the second group there are tactics that include experiments. Students who prefer these tactics like to put their acquired knowledge into practice as soon as possible.

6) *learning strategy* can be divided in detailed tactics with focus on small parts of particular information. From these small parts the "whole picture" is made. The second is the holistic tactics with focus on big parts of abstract information from which the student works their way to details.

7) *study conception* can be divided in contemplative, strategic and surface learning. In contemplative learning student aims to understand what they learn. In strategic learning student aims to be effective in their learning and wants to achieve the best results. In surface learning student aims to accomplish the minimal requirements only.

8) *Self-regulation* defines how much the student is able to control their learning process. If they are able to control their learning process successfully, they do not need any external help. If they are not able to control their learning process, they will need precise instruction.

Author's module

Learning material is important for students to be able to learn independently. The program must have different levels of curriculum conception and various sensory perception forms to correspond with the learning styles of specific students.

Each chapter of each topic delivers well structured instruction to student – chapters are divided into subchapters, paragraphs, etc. We call the smallest coherent part representing a unit of information the "framework". The framework is identical to the lowest level of a numbered text. Each particular framework is divided into an explanatory part, testing part and others (figure 2). The explanatory part is further divided into traditional parts of instruction – theoretical, semantic, consolidating and motivational. By combining the parts mentioned above we obtain different ways of instruction. For the testing part, various categories of questions, exercises and practical tasks have been chosen. The part "others" of a particular framework contains motivational, navigational and accomplishment layers. The

framework is also divided to variants, where each variant describes the same information in different way. There are four sensory variant that differs in multimedia used and three depth variants that differs in verbosity.

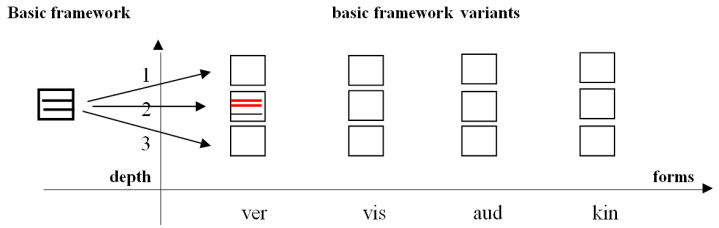

Figure 2: Variations of framework

Adaptive module

When we prepare adequate study materials (author's module) and include student characteristics (student's module), we lay down the foundations for the adaptive module. Creating the adaptive module was the most demanding. The key aspect was to define the rules that manage the selection of the most suitable parts of frameworks. Afterwards the framework is displayed to the student. Their knowledge is gradually tested in the form of theoretical questions and tasks. If the student finishes the framework successfully, they can continue in their study. Failing that, the student is offered a different approach to learn what they have not understood. There might either be a more detailed explanation or additional examples with further practical use. This should help students finish the framework successfully.

It is necessary to monitor all study activities of the student to know the progress of their study. Dynamic characteristics recorded from their study activities and from self-regulation should be added to the student's static characteristics entered at the beginning of their study. Information about their study activities will be gathered from progress tests.

Frequency of testing can differ – after each chapter, after a particular topic explained, after a study unit. The test results tell us whether the student learnt something new or not, whether they like the suggested strategy for their study or not. Monitoring these dynamic characteristics, a good adaptive algorithm can modify and improve the instruction approach such as changing the way of explanation, varying the way of practice, etc. Above all that, the adaptive algorithm should follow the study objectives and help students achieve these objectives.

Design of Adaptive Textbook

Methodology for the design of adaptive textbook stems from the general teaching principles of Jan Ámos Komenský, situated learning of Gagné and Bloom's taxonomy of learning objectives. These experts laid down the foundation of learning style strategies. They defined the rules and principles suitable for effective instruction.

When creating the methodology for the design of adaptive instruction materials we took all these teaching principles and the methodology of distance-learning textbook design into consideration.

We used the principle of illustration, self-consciousness, systematic approach, adequacy and permanence of Jan Ámos Komenský. Instruction methods follow the basic steps of study.

The Gagné's principle of situated learning was used in adaptive instruction as follows: introduction of the lesson, instruction, practice, testing and the end of the lesson. Bloom's theory to define learning objectives in adaptive study materials was used with emphasis on the cognitive area of knowledge. The objectives are defined in relation to the character of study. There are six categories – remember, understand, apply, analyze, evaluate, create [Gagné, 1975; Komenský, 1947 & 1948].

When considering the possibilities to be used in adaptive instruction we took the design of distance-learning study materials into consideration. One of these ideas is to divide a study material into smaller parts as chapters and subchapters. We call one coherent unit of study a "framework". One such unit includes one main topic. Explanation of a subtopic is in accordance with the theory of Gagné's situated learning. The framework is divided into smaller parts called "layers". The layers will make it possible to adapt the style of instruction to student's needs. What we call the layer of framework is that part of the framework that is homogenous in the steps undertaken during the instruction process (instruction, theory, explanation, practice, testing of knowledge, motivation, control of the lesson) [Kostolányová, 2011a].

Types of layers:

- **Explanatory**– group of layers containing their own explanation of the material covered. This concerns the following layers:
  - **T Theoretical** – containing theory: definition, terms, rules, algorithms, etc. In terms of education, this is the most important type of layer.
  - **S Semantic** – explaining the introduced terms, formally described theory, containing additional information to the theoretical layer, explaining correlations arising from the theory, etc.
  - **F Fixation** – with the aid of repetition, varied formulations and alternative concepts implemented into the wider context to make it easier to remember the theory.
  - **R Resolved examples –** contains examples of how to apply the theory, resolved "textbook" examples. For students, these are examples of solving given tasks.
  - **P Practical** – contains solving of examples from practice that use the theoretical knowledge.
- **Testing** – a group of layers for the regular testing of acquired knowledge, and fixation of this theoretical knowledge with the aid of tasks. *These layers are:*
  - **Questions** – theoretical questions from the material covered. Questions may only serve as control questions for the student, or adaptive algorithms may use them to control the next instruction.
  - **U Tasks** – "textbook" exercises to be resolved.
  - **X Practical exercises** – tasks from practice.
- **Other layers**
  - **M Motivational** – motivational information about the subject, lesson or framework, which would justify the benefit of study to the unmotivated student.

- **N Navigational** – didactic or organizational information, a certain guide for lessons or the material covered, recommended study methods, etc.

To understand the content of particular layers, we provide examples of some of them below:

Example of a layer focused on the objective of instruction

After finishing the study of this chapter, students will be able:

- to define the basic characteristics of vector and bitmap graphics
- when solving a practical task to define which type of graphics to use (according to advantages and disadvantages of each type)

Example of a motivational layer

Did you know that computers display graphics either in a vector or in a bitmap form? Have you seen any difference between these two forms so far? Don't worry and start our course. When you understand the difference between these two forms, you become more effective while working with graphics.

Example of a theoretical layer

Bitmap graphics depicts a picture with the help of pixels organized in the form of grid. Each pixel in the grid has a defined place and color so the picture is created as a mosaic.

Example of a semantic layer

When we modify a bitmap picture, we change pixels, not line segments and curves. Bitmap graphics depends on resolution because data describing the picture relate to the grid of a particular size. When we modify a bitmap picture, the quality of the image can change. The changes can be particularly visible when displaying a high resolution picture on a monitor with lower resolution. The image quality is low.

Designing the adaptive textbook is more demanding than designing a regular text or multimedia instruction support. A template was created for the authors who decided to participate in designing the adaptive textbook (Table 1). In this template, authors enter the text of instruction material and the use of multimedia components [Kostolányová, 2011c].

One part requires authors to enter specialized content of instruction (the major part of the template) and to the other, they enter relevant metadata needed to control adaptive instruction (right side of the template).

The authors of instruction materials in adaptive form create textual content, well structured into this template. They also enter the use of multimedia components. Detailed scenarios of how to create adaptive instruction materials are part of the adaptive textbook in the appendix form.

Subject: Subject name								
Lesson: Name of the lesson								
Rtitle = Framework title					FNum = **n**			
	Variant - level:				VLevel = **1-3**			
	Variant - form:				VForm=Sver,Sviz,Saud,Skin			
	Layer Content						**Layer Type**	**Layer Order**
	1. text of the layer T (text, picture, …)						**T**	**1**
	2. text of the layer T						**T**	**2**
	text of the layer S						**S**	**1**
	…						**S**	**2**
	text of the layer F						**F**	**1**
	Example:						**R**	**1**
	Practical task:						**P**	**1**
	text of the layer C						**C**	**1**
	text of the layer L						**L**	**1**
	text of the layer N						**N**	**1**
	text of the layer M						**M**	**1**
	Question 1	VrGroup=**1**	VrOblig=**O**	VrScore=**1**	VrResult=**P**		**O**	**1**
	Question definition … variable group 1							
					Question Score	**Question Type**	**Answer Correct**	**Question Order**
	Text of the variant 1				**0**	**Vnm**	**N**	
	…				**0**		**N**	
	Task 1	VrGroup=**2**	VrOblig=**P**	VrScore==**3**	VrResult=**P**		**U**	**1**
	Task definition… created group 2							
					Question Score	**Question Type**	**Answer Correct**	**Question Order**
	Answer 1 – correct				3	x	**A**	**1**
QReaction	Text - untypical verbal reaction to an answer 1							
	Answer 2 – partly correct				0	x	**N**	**2**
QReaction	Text – nonstandard verbal reaction to an answer 2, explanation							
	Answer 3 – incorrect, appears frequently				0	x	**N**	**3**
QReaction	Text – verbal reaction to answer 3, explanation							

Table 1 – Template to create adaptive study materials

Control of Instruction by Virtual Teacher

Each framework, divided into particular layers, will be created in four sensory forms (verbal, auditive, visual, kinesthetic) and in three levels of instruction (standard, with extra support and with extra interesting details for the student). Variants that include a form (sensory forms) and levels of instruction are not able to cover all detected distinctions in style of instruction. The instruction must react to other various characteristics of the student. Analyzing these student's characteristics, we concluded that the instruction can also differ in order of particular parts of instruction and can revise tests and organizational information if needed.

Adaptive algorithms will form the initial version of optimal instruction style. The algorithms function on the basis of predefined rules. The rules are created by experts in the field of pedagogy and in harmony with pedagogical and psychological principles. Below are examples of these rules:

- If the student's characteristics in the area of "Study Approach" = 75 (a detail oriented student), then use the level of instruction 2 and then the level of instruction 1 in the order defined by other rules.
- If the student's characteristics in the area of "Motivation" = -50 (strongly unmotivated), then use the "Motivational Level" 3 (describes a practical benefit of this knowledge in details).

etc. [Kostolányová, 2011a]

Intuitive rules are the mainstay to create other rules. The intuitive rules will come from analysis and research concerning the evaluation of instruction and test results. Principles of a good instruction style are defined in the rules. Such an instruction style should motivate students with bad study approach to use more effective methods and study approach.

The "virtual teacher" is responsible for controlling the instruction as well as for measuring the students' progress. Measuring students' progress, detecting their level of knowledge and comprehension of the presented information is an essential part of the adaptive system. The whole instruction process is recorded: every "click" of the student, exact time spent in particular layers, changing of student's strategy, test results, etc. Recorded data serve as a source to make differential analysis.

- to verify the settings of student's characteristics;
- to verify the suitability of instruction support;
- to verify expert rules of the virtual teacher.

Evaluation of Adaptive E-learning

The Barborka system was tested in teaching of five different subjects. The purpose of this method is to gather early feedback for the prototype of adaptive learning system and its adaptive supports. More than one hundred students participated in study of one part of some subject. These students had to fill learning style questionnaire at the beginning of the study. Virtual teacher chose appropriate teaching style for each student on the basis of the filled learning style questionnaire. Filling the evaluation questionnaire at the end of the study was optional, and only 46 students filled it.

Reliability of this questionnaire was computed using Cronbach's alpha [Cronbach, 1951]. This statistic measures the innter consistency of the questionnaire by using formula (1).

In this formula, n is number of questions, V_i is variance of scores on each question and V_{test} is total variance of overall scores on the entire questionnaire. Value of the Cronbach's alpha for this questionnaire is 0.83. Acceptable values should be greater then 0.7, so we can consider that this questionnaire has good inner consitency and is reliable.

Evaluation questionnaire asked students the following:

- Evaluation of the learning style questionnaire
- Description of their learning style
- Material
- Usage of different depths and variants
- Level of comfort of the system
- Evaluation of adaptive e-learning

Linked data from learning style questionnaires and evaluation questionnaires were analyzed by association rules and correlations.

Results

New learning style was found on the basis of data analysis. Many students described their learning style as text underlining and making notes. Many students also complained about the system working slowly.

Correlation analysis was done between the sensory type measured in learning style questionnaire and students' favorite sensory type of variant (see Table 2). Expected correlation was found only with the kinesthetic type that correlated with interest in kinesthetic variant. Auditive type correlated with interest in verbal variant and with lack of interest in kinesthetic variant. Verbal type correlated with kinesthetic variant.

	auditive	verbal	kinesthetic	visual
Visual is best	-0.21	0.12	-0.02	0.18
Kinesthetic is best	0.18	-0.33	0.23	-0.09
Auditive is best	0.12	0.10	-0.19	-0.10
Kinesthetic is interesting	-0.31	-0.11	0.44	0.07
Auditive is interesting	0.07	-0.17	0.10	0.01
Visual is interesting	-0.11	0.23	-0.26	0.16
Verbal is interesting	0.38	-0.17	-0.13	-0.18

Table 2: Correlation analysis

Association analysis discovered no interesting rules. Only the connection between sensory types was confirmed.

Students evaluated their first experience with adaptive e-learning as normal (see Figure 3). 39 % of students didn't know, 26 % was negative and 35% positive. But the majority of students (see Figure 4) believe that the adaptive e-learning can be useful in the future.

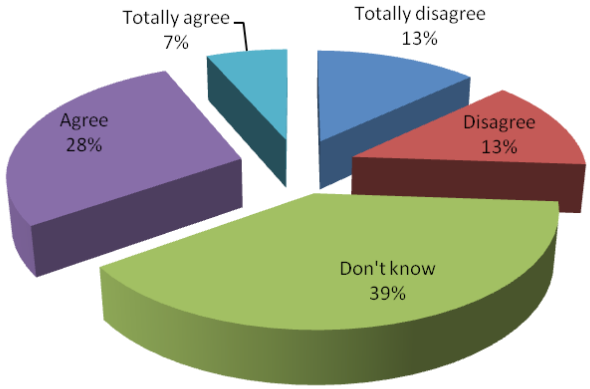

Figure 3: Is adaptive e-learning better than normal e-learning?

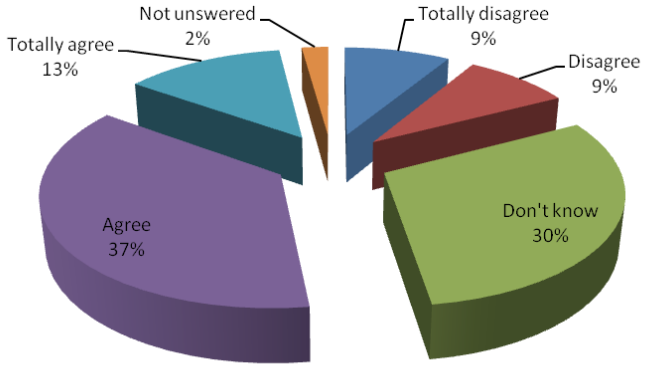

Figure 4: Can adaptive e-learning be useful in the future?

The clarity of the questionnaires and materials was evaluated positively (see Figure 5). Most of the students did not need any additional information or they found it in another depth.

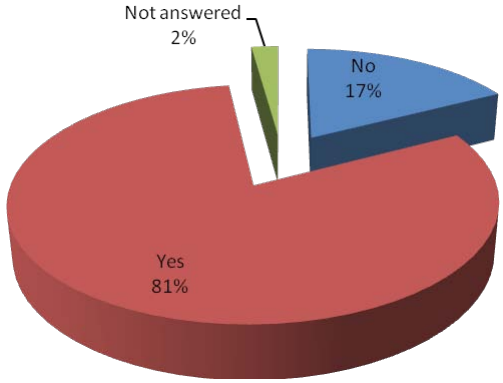

Figure 5: Were materials understandable?

Information in other depth was used only by half of the students and other sensory types of variants by 30 %. For most students the best variant was visual, and no one chose the verbal variant (see Figure 6).

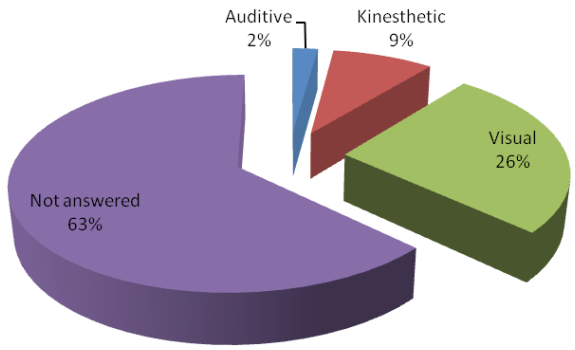

Figure 6: What sensory type of variant is best for you?

Discussion

Analysis was done only on a small sample of students, thus the conclusions are not entirely reliable. Correlation and association analyses did not confirm that sensory type measured by the learning style questionnaire determines what sensory type of variant is best for students. This correlation was discovered only with the kinesthetic type. This may be caused by incorrect measuring of the sensory type in the learning style questionnaire or by unsuitably created variants.

Students did not like the auditive variant according to the results of the evaluation questionnaire. This enabled authors of adaptive material to concentrate on more popular visual variants instead of auditive variants.

Conclusion

It should be noted that the execution of proposed adaptive instruction was not limited to theoretical work. Analysis of the software control system that automatically controls the whole instruction process is being done.

An adaptive LMS is implemented gradually on the basis of analysis results and is ready to be tested. When testing the adaptive LMS, some adjustments can be made in the area of student's characteristics as well as in the area of virtual teacher rules.

The advantage of this control system is that the theoretical parts implemented are of dynamic and parametrical nature. That means that if any adjustment needs to be made, it can be made by entering data in a database and not by adjusting the whole structure of the control system. Specifically the rules of the virtual teacher are saved in a special expert database. Among the standard user roles as "student", "author", "teacher" and "administrator" there is also the "expert" role. The "expert" is a specialist in the field of adaptive instruction who has access to the records and adjustments of parameters that control the adaptive instruction. Thus the "expert" can modify relevant data and instruction on the basis of teaching instruction analysis.

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COPING STRATEGIES ADOPTED BY UNIVERSITY STUDENTS - PART II: ROLE CONFLICT AND AGE

Ludmila Natovová, Hana Chýlová

Czech University of Life Sciences Prague
brozovai@pef.czu.cz

Abstract

This study examines the particularities of various stress coping strategies (measured by standardized stress coping strategies questionnaire SVF 78) used by undergraduate university students (N=177). The first part was focused on gender differences. Part II compares groups differing in age and level of family-school-work conflict, drawing on the division according to the type of study: Part-time (N=102) and Full-time (N=75) students as well as on the age distinction (age<23: N=95, age>24: N=82). The findings indicate that there are age differences, as well as differences between the groups of part-time and full-time students, in the use of stress coping strategies, especially regarding the use of the positive triad: situation control, reaction control and positive self-instruction.

Key Words

Age, coping strategy, role conflict, stress, university education

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Introduction

The issue of stress, as a common phenomenon of a contemporary, globally developing society, is studied from the research as well as practical side by many scientific disciplines such as psychosomatic or behavioural medicine, biology, psychology, sociology and pedagogy. Research into stress, coping strategies, well-being, healthy lifestyles and risk-preventing behaviour has its own irreplaceable role within pedagogical and psychological counselling work with university students.

The authors of this paper examined the particularities of various stress coping strategies (measured by standardized stress coping strategies questionnaire SVF 78) used by undergraduate university students. The first part of the results was described in: "Stress coping strategies among university students – part I: Gender differences" (Chýlová and Natovová, 2012). That paper explicitly dealt with a comparative analysis of the role of gender as a variable in relation to stress coping strategies, and the balance between the use of positive and negative strategies. The present paper (part II) focuses on other variables which play an important role in preferred stress coping strategies. The theories of stress and stress coping strategies were already described to a considerable extent in the previous paper. This part is focused directly on the specifics of the two primary remaining variables: role conflict and age. Nevertheless, the concept of coping will be defined briefly. Carver (2011, p. 222) defines coping as "efforts to deal with a threatening or harmful situation, either to remove the threat or to diminish the ways in which it can have an adverse impact on the person."

A relationship between coping and psychological well-being has been found in a number of studies. One of the most influential is Folkman et al. (1987), who also focused on age differences in stress and coping processes, and clearly demonstrated the role of age in coping. They formulated three predictions; the third one involves an interaction between gender and age. However, they also mention a so-called "contextual interpretation", which suggests that there should be no age differences in the ways people cope with similar sources of stress.

A study conducted in Italy (Cicognani, 2011), which examined coping strategies for minor stressors in adolescence, suggests that the majority of adolescents are successful in coping and productive adaptation – the most frequently used strategies in that study were active and internally focused.

The effect of age, as a variable affecting the relationship between stressors and performance, has received attention in the occupational stress literature for quite some time, even though the attention that has been given to this demographic variable has been, according to Jex (1998), more conceptual than empirical.

One of the major approaches to the stress process is the role stress model. Griffin and Clarke (2011, p. 362) assume that "the process through which work roles create the experience of stress was one of the earliest and most fruitful approaches to work stress." These authors (Griffin and Clarke, 2011) also define role conflict as two or more sets of incompatible work demands, and role overload is considered a particular form of role conflict.

The moderator role of coping (problem-, emotion-, and avoidance-focused coping strategies) between work-to-family and family-to-work conflict and well-being (work engagement, job satisfaction, and family satisfaction) was examined by Rantanen (2011). Analyses showed that emotion-focused coping buffered against job dissatisfaction in a strong family-to-work conflict situation. On the other hand, emotion-focused coping was harmful for family satisfaction in the same stressful situation: Those who used more emotion-focused coping were

less satisfied with their family life under the conditions of strong family-to-work conflict. Furthermore, avoidance coping was beneficial in a strong family-to-work conflict situation: Those who used more avoidance coping were more satisfied with their family life in this situation.

Baltes, Zhdanova and Clark (2011) examined the processes through which personality characteristics can influence work–family conflict. Specifically, they tested the mediating effects of selection, optimization, and compensation behavioural stress-coping strategies on the relationship between personality characteristics and work–family conflict. Conscientiousness and agreeableness were related to greater usage of work and family behavioural coping strategies, and these behavioural strategies influenced the levels of work–family conflict that were experienced. Work interference with family, as well as family interference with work, were found to have negative direct effects, and emotional stability was found to have a direct effect on that conflict. The findings suggest that different processes underlie the influence of specific personality characteristics on the work–family conflict.

The role conflict of a student-worker-mother/father is particularly expressed in the group of part-time students, and also in the older group of students. Coping mechanisms of students were studied by, among others, Caplan, Naidu and Tripathi (1984), who studied coping mechanisms used by a group of university students facing the stress of annual examination. Their results suggest that coping may mitigate the effects of stressors on well-being only when the stressors are subjectively controllable. A study by McLaughlin, Cormier and Cormier (1988) closely examined the relationship between time-management and self-care coping techniques used by multiple-role women, and their self-reported levels of distress, stress and marital adjustment. The results of the study indicated that the number, type and frequency of use of coping strategies were significantly related to the self-reported level of distress and stress.

Role conflict and age specifics, being variables in the use of different stress coping techniques and having an influence on students' well-being, is the subject matter of this text.

Materials and Methods

Group of respondents

The Czech version of the Stress Coping Style Questionnaire SVF 78 was administered to 177 undergraduate students from September 2011 to January 2012. The sample consisted of 63 males and 114 females in the age range from 19 to 49 years. Of the total number of 177 students, 102 were part-time students and 75 were full-time students at the Faculty of Economics and Management (FEM) at the Czech University of Life Sciences (CULS) within the study programmes Public Administration, Regional Development, and Business and Administration. 95 students were 23 years old or younger, and the group of older students consisted of 82 students. Even though students typically finish their university studies around the age of 23, this is often not the case, and therefore merely age and/or type of study cannot be considered all-inclusive categories. We expect that role conflict, mainly for part-time students, and the age variable of any student will be important moderators of stress coping strategies.

The subjects were not paid. Further descriptive characteristics are presented in Tab. 1, below.

	N	Mean Age	Stand. dev.	Min. Age	Max. Age	Women (N)	Women (%)	School-work-family conflict (%)
Part-time students	102	30, 17	7, 44	20	49	52	50, 98	100*
Full-time students	75	20, 89	0, 92	19	26	62	82, 67	0*
Younger students (19-23)	95	20,92	0, 83	19	23	64	67,4	22,1
Older students (24-49)	82	32,4	6,57	24	49	50	61,0	98,8
Total	177	26, 24	7, 29	19	49	114	64, 41	57,6

*expected value (no input data)

Tab. 1: Descriptive characteristics of subgroups of respondents.

The method

In the Czech version of the SVF 78 questionnaire, subjects decide for each item how likely the reaction presented corresponds to his or her way of reacting, when he/she is "disturbed, irritated or upset by something or someone" (Weyers et al, 2005; Janke and Erdmann, 2003). The inventory contains 78 items and has 13 subscales. Scales 1 – 7 are assumed as positive coping strategies, scales 10 – 13 as negative coping strategies. Scales (and their abbreviations, which are used also further in the text) with short descriptions and sample-items are summarized in Tab. 2.

Abbrev.	Name	Description	Sample-item
MIN	Minimization	devaluate intensity, duration or importance of stress	I tell myself that everything will turn out all right
DENGU	Denial of Guilt	stress one's missing personal responsibility	I think that I am not responsible for the situation
DISTR	Distraction	distract from stress related activities/situations or turn to stress incompatible ones	I try to distract myself
SUB	Substitute Gratification	turn to positive activities/ situations	I grant myself something I've desired for a long time
SITCON	Situation Control	analyze the situation, plan actions and act for control and problem solving	I plan how to solve the difficulties involved
RECON	Response Control	bring or keep one's own reactions under control	I tell myself I must not lose my temper
POSI	Positive Self-instructions	encourage oneself competence and the ability to control	I tell myself that I can cope with this
SOCSUP	Need for Social Support	look out for somebody to talk to, for social support and help	I try to talk with someone about the problem
AVOID	Avoidance	resolve to prevent or avoid stressful situations	I resolve to avoid such situations in the future
ESC	Escape	(resignative) tendency to escape a stressful situation	I tend to run away from the situation
RUMI	Rumination	ruminate, not being able to break off from one's thoughts	I keep thinking about the situation for a long time afterwards
RES	Resignation	give up with feelings of helplessness, hopelessness	I tend to give up
SEBLA	Self-blame	attribute stress to one's own mistakes	I blame myself

Tab. 2: SVF78 Subtests and Categories (Weyers et al, 2005).

Statistical Analyses

As was mentioned above, this study attempts to identify differences in the use of coping strategies by students in different study modes, specifically in the full-time and part-time studies. With respect to findings cited in Introduction, we have formulated first hypothesis that there are statistically significant differences in the use of coping strategies between the group of full-time students and the group of part-time students, identified through the SVF 78 questionnaire. The second hypothesis assumes significant differences in the use of coping strategies between younger (age 18 – 23) and older (age 24 – 50) participants. To identify differences between each group of participants (full-time students, part-time students, students in age group 18 – 23 years, student in age group 24 – 50 years) and standardized sample from Czech population we use one sample t test. To test the null hypothesis of non-existence of a significant difference between the two groups, we used a t test for two independent samples (Norušis, 2011). Before each testing, the null hypothesis of no difference in the variance of the evaluated variable values in both groups was adopted based on Levene's Test for Equality of Variances.

Results

With regard to the above-mentioned hypotheses, the results presented below are logically divided into two parts. First, we refer to the differences between students of the two types of study and a standardized Czech population sample (Tab. 3), and also between both groups of students according to their study mode (Tab. 4). The second part of the results includes an age differentiated comparison of our sample to the Czech population sample (Tab. 5), as well as a mutual comparison of both age groups (Tab. 6). The first question posed was whether one of our groups (full-time or part-time students) is more similar to the standardized Czech population sample than the other group. Tab. 3, below, shows the results of one sample t-test for each of these groups, for all observed coping strategies.

Strategy	study mode	t	df	Sig. (2-tailed)	Mean Diff.	95% Confidence Interval of the Difference		Test Value
						Lower	Upper	
MIN	Part-time	4,73	101	0,00**	2,37	1,38	3,37	9.48
	Full-time	0,00	74	1,00	0,00	-1,21	1,21	
DENGU	Part-time	2,27	101	0,03*	0,84	0,11	1,57	10.71
	Full-time	0,76	74	0,45	0,38	-0,63	1,39	
DISTR	Part-time	1,35	101	0,18	0,56	-0,27	1,39	11.83
	Full-time	3,30	74	0,00**	1,44	0,57	2,30	
SUB	Part-time	5,84	101	0,00**	2,51	1,66	3,37	8.91
	Full-time	6,81	74	0,00**	3,32	2,35	4,29	
SITCON	Part-time	-0,36	101	0,72	-0,13	-0,88	0,61	16.78
	Full-time	-4,12	74	0,00**	-2,05	-3,04	-1,06	
RECON	Part-time	1,51	101	0,13	0,57	-0,18	1,32	15.41
	Full-time	-1,40	74	0,17	-0,61	-1,48	0,26	
POSI	Part-time	-0,481	101	0,63	-0,22	-1,14	0,70	16.37
	Full-time	-3,74	74	0,00**	-2,01	-3,08	-0,94	

SOCSUP	Part-time	4,35	101	0,00**	2,19	1,19	3,19	12,89
	Full-time	5,28	74	0,00**	2,98	1,85	4,10	
AVOID	Part-time	8,45	101	0,00**	3,35	2,57	4,14	11.97
	Full-time	5,05	74	0,00**	2,76	1,67	3,86	
ESC	Part-time	6,33	101	0,00**	2,84	1,95	3,73	8.24
	Full-time	7,51	74	0,00**	3,77	2,77	4,77	
RUMI	Part-time	0,30	101	0,77	0,15	-0,87	1,18	15.13
	Full-time	0,42	74	0,68	0,27	-1,01	1,55	
RES	Part-time	1,90	101	0,06	1,00	-0,04	2,04	8.04
	Full-time	4,82	74	0,00**	2,60	1,53	3,67	
SEBLA	Part-time	1,84	101	0,07	,87	-0,07	1,81	10.64
	Full-time	1,82	74	0,07	1,15	-0,11	2,40	
Positive strategies total	Part-time	5,82	101	0,00**	1,49	0,98	2,00	12.22
	Full-time	1,90	74	0,06	0,63	-0,03	1,29	
Negative strategies total	Part-time	2,87	101	0,01**	1,21	0,37	2,04	10.52
	Full-time	4,18	74	0,00**	1,94	1,02	2,86	

*$\alpha \leq 0.05$; ** $\alpha \leq 0.01$; N (part-time) = 102; N (full-time) = 75

Tab. 3: Results – descriptive statistics and one sample t-test of study modes

As shown in Tab. 3, some significant differences were identified between the observed groups of students, according to their study mode, and the entire Czech population (mean values of each strategy are presented in Tab. 4, below). Part-time students use some of the positive strategies, such as minimization, denial of guilt and substitution, significantly more often. Full-time students use the strategies of distraction, substitution and resignation more often than participants from the standardized sample, but use the strategies of controlling the situation and giving oneself positive instructions significantly less. This fact is important for counselling work and also for training and educative activities in some of the subjects taught in the department of psychology (e.g., Mental hygiene), and it will also be scrutinized with regard to age-differentiated groups. Both of our groups (full-time and part-time students) use the neutral strategies of seeking social support and avoiding stressors, as well as the strategy of escaping stressful situations, more frequently.

With regard to the above-mentioned hypotheses, in each of the two independent samples (full-time students and part-time students), we separately tested the average values of each variable – i.e., coping strategies identified through the SVF 78 questionnaire (described in detail in Tab. 2 above). Tab. 4, below, summarizes the descriptive characteristics of each variable, Levene's test results and the t-test results for two independent samples.

Strategy	Type of study	Mean	Std. Dev.	Levene's tests F	Levene's tests Sig.	t tests t	t tests Sig.	Mean Diff.	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
MIN	Part-time	11,85	5,07	0,17	0,68	3,03	0,00**	2,37	0,83	3,92
	Full-time	9,48	5,24							
DENGU	Part-time	11,55	3,73	0,85	0,36	0,74	0,46	0,46	-0,75	1,66
	Full-time	11,09	4,40							
DISTR	Part-time	12,39	4,22	1,51	0,22	-1,43	0,16	-0,87	-2,09	0,34
	Full-time	13,27	3,77							
SUB	Part-time	11,42	4,35	0,49	0,49	-1,23	0,22	-0,81	-2,09	0,48
	Full-time	12,23	4,22							
SITCON	Part-time	16,65	3,79	1,79	0,18	3,14	0,02*	1,91	0,71	3,12
	Full-time	14,73	4,30							
RECON	Part-time	15,98	3,81	0,00	0,99	2,05	0,04*	1,18	0,04	2,32
	Full-time	14,80	3,77							
POSI	Part-time	16,15	4,68	0,09	0,77	2,52	0,01**	1,79	0,39	3,19
	Full-time	14,36	4,66							
SOCSUP	Part-time	15,08	5,09	1,19	0,28	-1,04	0,30	-0,79	-2,29	0,71
	Full-time	15,87	4,88							
AVOID	Part-time	15,32	4,01	2,00	0,16	0,90	0,37	0,59	-0,71	1,89
	Full-time	14,73	4,74							
ESC	Part-time	11,08	4,53	0,00	1,00	-1,38	0,17	-0,93	-2,27	0,40
	Full-time	12,01	4,35							
RUMI	Part-time	15,28	5,20	1,24	0,27	-0,14	0,89	-0,12	-1,73	1,49
	Full-time	15,40	5,58							
RES	Part-time	9,04	5,31	2,08	0,15	-2,08	0,04*	-1,60	-3,12	-0,08
	Full-time	10,64	4,67							
SEBLA	Part-time	11,51	4,77	1,45	0,23	-0,36	0,72	-0,28	-1,80	1,24
	Full-time	11,79	5,45							

Positive strategies total	Part-time	13,71	2,59	0,31	0,58	2,09	0,038*	0,86	0,05	1,68
	Full-time	12,85	2,87							
Negative strategies total	Part-time	11,72	4,25	0,25	0,62	-1,16	0,25	-0,73	-1,98	0,51
	Full-time	12,46	4,02							

*$\alpha \leq 0.05$; ** $\alpha \leq 0.01$; N (part-time) = 102; N(full-time) = 75; df=176

Tab. 4: Results – descriptive statistics and two independent samples t-tests for each coping strategy, with Levene´s Tests for Equality of Variances

Data in Tab. 4 indicate a significant difference in the use of the minimization, situation control, response control and positive self-instruction strategies. Among the negative strategies, only the difference in the use of the resignation strategy has proved significant. In relation to the descriptive characteristics of the evaluated variable, we can also state that a strategy was used more frequently in the group of full-time or part-time students.

As for the minimization strategy, it consists in an intentional or conscious reduction in the intensity, duration or importance of a stressor in a particular situation. This strategy is classified as a positive coping strategy, and its more frequent use among part-time students (also according to the entire Czech population, as presented above) may be related to their different life experience, given the higher age of students in this group; compare Tab. 1. The three strategies of situation control, response control and positive self-instruction are described by the SVF 78 questionnaire authors (Janke and Erdmann, 2003) as a separate triplet, ranking among the positive coping strategies which prove to be the most constructive in coping with stress. In practice, we can say that the use of these three positive coping strategies can be a good predictor of dealing with stressful situations, and is associated, though probably not entirely, with handling the demands of part-time university study. The last significant difference identified in our sample was that part-time students used the resignation strategy less than full-time students; nevertheless, both of the observed groups scored significantly higher in this strategy than the Czech population sample. This strategy is one of the non-constructive, negative strategies of coping with stress. However, with respect to the use of this strategy by full-time students, psychological interventions during face-to-face instruction need to be considered, such as the presentation of topics related to the causal attribution theory, locus of control or logotherapeutic approach.

With regard to the hypotheses of significant differences in the use of coping strategies, in both age groups and in each of the two independent samples (younger students of age 18 - 23 years and older students of age 24 – 50 years), we separately tested the average values of each variable – i.e., coping strategies identified through the SVF 78 questionnaire (described in detail in Tab. 2 above). The second question posed was whether one of our groups (younger or older students) is more similar to the standardized Czech population sample than the other group. Tab. 5 shows the results of one sample t-test for each of these groups, for all coping strategies. Tab. 6 summarizes the descriptive characteristics of each variable, Levene's test results and the t-test results for two independent samples.

Strategy	Age group	t	df	Sig. (2-tailed)	Mean Diff.	95% Confidence Interval of the Difference		Test Value
						Lower	Upper	
MIN	18 - 23	0,93	94	0,35	0,52	-0,59	1,63	9.48
	24 - 50	4,33	81	0,00**	2,35	1,27	3,43	
DENGU	18 - 23	0,56	94	0,58	0,24	-0,61	1,09	10.71
	24 - 50	2,66	81	0,01**	1,12	0,28	1,96	
DISTR	18 - 23	3,45	94	0,00**	1,42	0,60	2,24	11.83
	24 - 50	0,82	81	0,41	0,37	-0,52	1,25	
SUB	18 - 23	7,48	94	0,00**	3,13	2,30	3,96	8.91
	24 - 50	5,04	81	0,00**	2,53	1,53	3,53	
SITCON	18 - 23	-4,13	94	0,00**	-1,77	-2,62	-0,92	16.78
	24 - 50	0,03	81	0,98	0,01	-0,83	0,86	
RECON	18 - 23	-1,25	94	0,22	-0,48	-1,25	0,29	15.41
	24 - 50	1,69	81	0,09	0,71	-0,12	1,55	
POSI	18 - 23	-3,60	94	0,00**	-1,78	-2,76	-0,80	16.37
	24 - 50	-0,11	81	0,92	-0,05	-1,04	0,93	
SOCSUP	18 - 23	5,73	94	0,00**	2,93	1,92	3,95	12,89
	24 - 50	3,71	81	0,00**	2,05	0,95	3,15	
AVOID	18 - 23	6,57	94	0,00**	3,02	2,11	3,93	11.97
	24 - 50	6,93	81	0,00**	3,20	2,28	4,12	
ESC	18 - 23	8,69	94	0,00**	3,82	2,95	4,70	8.24
	24 - 50	5,03	81	0,00**	2,55	1,54	3,56	
RUMI	18 - 23	0,12	94	0,90	0,07	-1,05	1,19	15.13
	24 - 50	0,63	81	0,53	0,36	-0,78	1,50	
RES	18 - 23	4,64	94	0,00**	2,34	1,34	3,34	8.04
	24 - 50	1,58	81	0,12	0,91	-0,24	2,06	
SEBLA	18 - 23	2,34	94	0,02*	1,27	0,19	2,34	10.64
	24 – 50	1,25	81	0,21	0,66	-0,39	1,72	
Positive strategies total	18 - 23	2,53	94	0,01**	0,75	0,16	1,33	12.22
	24 - 50	5,64	81	0,00**	1,57	1,02	2,12	
Negative strategies total	18 - 23	4,43	94	0,00**	1,87	1,03	2,70	10.52
	24 - 50	2,40	81	0,02*	1,11	0,19	2,04	

*$\alpha \leq 0.05$, ** $\alpha \leq 0.01$, N(18 – 23) = 95, N(24 – 50) = 82

Tab. 5: Results – descriptive statistics and one sample t-test of each age group coping strategies compared to the population sample

As in the case of full-time and part-time students, in this case we can also identify significant differences between older students and participants from the Czech population sample with regard to the strategy of minimization and denial of guilt (older students use these strategies more frequently). Younger students use the strategies of distraction, resignation and self-blame (resignation and self-blame are clearly negative coping strategies) more frequently than the Czech population, but the strategies of positive self-instruction and situation control less frequently. Both of our groups use the strategies of substitution,

social support, avoidance and escaping more often than the Czech population sample.

Strategy	Age group	Mean	Std. Dev.	Levene's tests F	Levene's tests Sig.	t tests t	t tests Sig.	Mean Diff.	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
MIN	18 - 23	10,00	5,43	1,16	0,28	-2,34	0,02*	-1,83	-3,38	-0,28
	24 - 50	11,83	4,91							
DENGU	18 - 23	10,95	4,17	0,33	0,57	-1,46	0,15	-0,88	-2,07	0,31
	24 - 50	11,83	3,81							
DISTR	18 - 23	13,25	4,02	0,28	0,60	1,74	0,08	1,06	-0,14	2,25
	24 - 50	12,20	4,02							
SUB	18 - 23	12,04	4,08	2,33	0,13	0,93	0,35	0,60	-0,68	1,88
	24 - 50	11,44	4,54							
SITCON	18 - 23	15,01	4,18	0,95	0,33	-2,94	0,00**	-1,78	-2,98	-0,58
	24 - 50	16,79	3,84							
RECON	18 - 23	14,93	3,77	0,03	0,28	2,45	0,02*	-1,73	-3,12	-0,34
	24 - 50	16,12	3,81							
POSI	18 - 23	14,59	4,82	1,16	0,28	-2,45	0,02*	-1,73	-3,12	-0,34
	24 - 50	16,32	4,49							
SOCSUP	18 - 23	15,82	4,99	0,08	0,78	1,17	0,24	0,88	-0,60	2,37
	24 - 50	14,94	5,01							
AVOID	18 - 23	14,99	4,48	0,22	0,64	-0,28	0,78	-0,18	-1,47	1,11
	24 - 50	15,17	4,18							
ESC	18 - 23	12,06	4,29	0,07	0,79	1,90	0,06	1,27	-0,05	2,59
	24 - 50	10,79	4,59							
RUMI	18 - 23	15,20	5,51	1,55	0,22	-0,36	0,72	-0,29	-1,88	1,31
	24 - 50	15,49	5,18							
RES	18 - 23	10,38	4,92	0,95	0,33	1,87	0,06	1,43	-0,78	2,93
	24 - 50	8,95	5,22							
SEBLA	18 - 23	11,90	5,27	1,68	0,20	0,79	0,43	0,60	-0,90	2,11
	24 - 50	11,30	4,80							

Positive strategies total	18 - 23	12,97	2,87	0,77	0,38	-2,01	0,05*	-0,82	-1,63	-0,01
	24 - 50	13,79	2,52							
Negative strategies total	18 - 23	12,39	4,11	0,00	0,99	1,20	0,23	0,75	-0,48	1,99
	24 - 50	11,63	4,20							

*$\alpha \leq 0.05$, ** $\alpha \leq 0.01$, N(18 – 23) = 95, N(24 – 50) = 82

Tab. 6: Results - descriptive statistics and two independent samples t-tests for each coping strategy in both age groups, with Levene´s Tests for Equality of Variances

When comparing younger and older students, we can find significant differences in the use of minimization, and also in the use of the positive triad – situation control, reaction control and positive self-instruction. The last significant difference we identified is in the use of the resignation strategy – older students use this strategy less than younger students.

Discussion

First of all, it is necessary to answer the question: Why is it important to identify and measure the coping strategies of students? This question can be answered in many ways, but from our point of view the most important fact is that stress is usually considered an every-day factor influencing a person's health, achievement, work and social behaviour (Griffin and Clarke, 2011). For that reason, students should include health-related behaviour and mostly positive strategies of coping with stress in their behaviour repertoire.

Brunel and Grima (2010) specifically aimed to shed light on the ways in which working students manage their work and school activities. On the basis of questionnaire responses garnered from French working students, they showed that coping strategies implemented to deal with the stress which arises from the work-school conflict are generally effective, with the exceptions of self-accusation and cognitive repression. Furthermore, a negative relationship between work-school conflict, stress and turnover intention emerges. This study goes beyond mere one-dimensional illustrations which portray students as being under pressure or taking action to foster their own professional development, and instead suggests a combined response to role conflict which involves both confronting the conflict and managing emotions.

This study approached the differences in the use of stress coping strategies from two opposing points of view. The first one suggests that role conflict would be the important variable within the process of selecting coping strategies. The second one (according to Folkman et al, 1987, called *contextual interpretation*) assumes that the use of coping strategies should be more influenced by the specific context, and therefore is the result of what people must cope with as they age, rather than by age itself. The minor differences in the results of both tested hypotheses are most likely due to the relatively small extent of the age rank of the older group of respondents.

Weyers, Ising and Janke (2005) conclude that coping questionnaires, which are based on a dispositional approach and ask about the normal way of reacting in stressful situations, are valid for a certain range of stress intensities, covering most of the considerable range of the intensity dimension. Processing SVF 78 results enables us to analyze stress reduction strategies (positive strategies such as situation control, positive self-instruction and denial of guilt) or stress intensification strategies (negative strategies such as resignation and rumination). In

terms of psychometric characteristics, SVF 78 shows high levels of reliability and time stability, consistent construct validity, and considerable external validity with regard to other stress coping inventories (Janke and Erdmann, 2003; Weyers et al, 2005).

Conclusion

Significantly higher use of the three optimal coping strategies – situation control, reaction control and positive self-instructions – by part-time students and older students compared to younger and full-time students, presents the most important finding of this study. Both groups of older students and part-time students don´t differ significantly from the Czech population sample. Groups of younger students and full-time students do differ, but in a negative way. Part-time students (as well as older students) also use the minimization strategy more frequently and the resignation strategy less frequently than full-time students and younger students in our sample. However, our sample has its limitations (students of the FEM CULS, prevalence of females), which is why the research results cannot be generalized to the entire Czech population. In this context it could be advisable to extend the further research into the students' well-being and personality issues. Authors consider the results of the research inspiring and thought-provoking, especially in the context of higher education and psychological counselling on prevention of risk behaviour.

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COMPARATIVE STUDY OF ONGOING ADULT LEARNING IN PUBLIC SERVICES AND NON-PROFIT SECTOR (CASE STUDY)

Pavla Varvažovská, Martina Jarkovská

Czech University of Life Sciences Prague
varvazovska@pef.czu.cz

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Abstract

The aim of this paper is to compare the diversity of lifelong learning in public administration and non-profit sector and determine whether after 2009 there have been financial changes in the field of lifelong education of economically active population in selected institutions. Introduction presents a theoretical definition of life-long learning specifics and the comparison of life-long learning in public administration and non-profit sector according to different thematic classifications where their differences are significant. It concerns a general view of life-long learning in comparative areas, its significance, differences in legislation, reasons of motivation and, on the contrary, barriers. Practical part of the paper focuses on a sector quantitative and qualitative research carried out within a wider field survey. Conclusion of the paper demonstrates by the method of comparison differences in the need for education within public administration institutions and non-profit organizations.

Key Words

lifelong learning, education programmes, lifelong education programmes, motivation, training, public administration, non-profit sector

Introduction

In the last few years lifelong learning has become a major trend in all developed countries. Generally, an emphasis is put on increasing investment into human capital because educated society is a principal prerequisite for economic growth and the growth of inhabitants' standard of living.

Lifelong learning is to be competitive so that the inhabitants can compete with work force from abroad, which also influences economic potential of the society where they live. Professionally oriented adult learning can in some ways be an impulse for certain changes in economy as well as in the society (Mužík, 2000).

Lifelong learning is a significant part of adult learning and it presents a principal change in the notion of the whole education system. Increasingly, it is being perceived as a necessity to achieve higher effectiveness and competitiveness at the labour market. The concept of lifelong learning is to provide the possibilities of education in different educational phases of life and development of man (Mužík, 2000). Lifelong learning, as its name says, is understood as an active approach to education process. We can speak about a targeted education process mediated by learning (Mužík, 2000). Sometime the two notions of lifelong education and lifelong learning are confused. This is also caused by the same translation of the English "Lifelong learning". However, by lifelong learning we understand rather non-organized learning whereas lifelong education focuses on the education of both formal and informal kind.

From the viewpoint of lifelong learning, in 2007 the Government of the Czech Republic accepted one of the most important programme documents entitled the Strategy of lifelong learning in the CR for the period 2007-2015, which is supposed to serve as an initial programme document. Another document appealing to lifelong learning in terms of economic development is the Convergence programme of the CR, setting a direction which the Czech economy should follow in order to meet Maastricht criteria[1] (Lifelong learning strategy CR, 2007).

The concept of public administration covers a lot of activities. Firstly, by public administration we understand the administration of a particular territory, public issues, finances, education etc. Individual activities are managed by particular ministries, and they are governed and limited by legislation concerning a particular resort or area. Public administration organisations provide services to the citizens. Public administration is primarily divided into civil service and self-government.

Non-profit sector can be characterised as an area whose main objective is not business and which does not make profit to be distributed among its owners. It does make a profit, but it is invested back into the company for its further development. Public administration workers take part in lifelong learning because it is an area reflecting the impact of modern technologies and progress which needs to be closely followed. In the civil service the way of lifelong learning is modified by law (Act No 312/2002 Coll., on the employees of autonomous territorial units). Individual top sub-sections of public administration appeal to lifelong learning not only for their staff but also for the public by means of various projects. Accepting the principle of lifelong learning is in this work segment anchored in legislation (Mužík, 2000). Apart from classical present-day form lectures, the learning of chief officers and office managers can also be done by e-learning. Such a form is less expensive than the participation of officers and chief officers in classical courses.

1 The height of public deficit, price stability, the stability of long-term interest rates and exchange rate.

However, not everyone finds e-learning convenient. The disadvantage of this type of learning rests in the fact that it is a non-contact type of learning. On the contrary, the advantage of e-learning is the possibility of selecting convenient time for learning which suits the course participant and the possibility to return repeatedly to the studied material.

Armstrong (2007) says that e-learning programmes can relate to any usual corporate progress or process, orientation and learning programme as well as the development of skills in information technologies. However, they are not effective for developing "soft" skills such as creating teams or communication or presentation abilities based on personal contacts.

It is not important how the employee trains but it is important that the training brings an expected effect to the organization. Pike (2003) stresses the fact that the objective of any learning programme is to bring constant results in the form of staff efficiency. In their study, Casagranda et al (2010) evaluate the results and experience from distance learning and the use of e-learning platform. The objective of the study is to identify a mixed model also related to the use of technological instruments which are able to support lifelong learning and define dynamics and the process concerning the facilitation of learning activity.

Generally, when setting up education models, it is necessary to respect the efficiency of education, maintain a good ratio of activities (differing training methods, the lengths of activities, physical environment, and format), learn in segments and ensure the train of thoughts. For every model it is ideal to calculate costs per participant and the contributions of participants within efficient practical usage. Investments into the training of employees can be evaluated from a long-term perspective only, as the finances invested into the training of employees can return to employers in the form of more efficient work of their employees after some time distance.

In their analysis of an educational course for public sector managers, Katharaki et al (2009) state the importance of a detailed evaluation of the efficiency of the course on the basis of previously stated criteria and parameters using such methods as questionnaires, comments, observations and team discussions. Through this process, weak and strong points of the seminar were determined. Evaluation criteria can set up a certain model for course evaluation and on the basis of such evaluation they create a new approach to lifelong education and specialist preparation of other seminars and their efficiency. The evaluation criteria enabling the perception of the seminar level directly to its participants can be applied to proposing the models of future seminars.

The situation in the non-profit sector is vastly different from the situation in the public sector. There is no legislative modification for lifelong learning in this sector and for the staff in non-profit sector further learning is not compulsory. Therefore the employer cannot impose further learning on its employees with reference to superior regulations. However, it can be included in the work contract in correspondence with the Labour Code as one of the conditions of employment that the employee will further develop and increase his or her professional qualification by fulfilling partial and exactly defined, controllable tasks. It can be followed by financial benefits or pay rise and the development of non-claimable salary components. Such an approach and principle would definitely be a great contribution to the non-profit organisation.

The importance of lifelong learning within non-profit sector does not reach such significance as in the above mentioned public administration. From the above mentioned description

it is obvious that public administration workers have to learn because it is prescribed by the legislation. Many of them have to increase, deepen or complete their qualification if they wish to keep their work place. This fact is a significant impulse for an active approach to the matter.

Non-profit sector workers do not have such regulations. Their further learning depends on financial possibilities and their will. As the name suggests, it is after all a non-profit sector. Therefore the question arises whether such organisations will dispose of financial means set aside for their employees' further learning. In case of public administration, there are set aside financial means for staff training. Projects are also financed from public means for education provided it does not concern projects endowed by European structural funds supporting education and competitiveness. However, even in this segment of labour market a higher activity of employees can be achieved by way of labour-law motivation.

The objective of our paper is to find out which factors influence lifelong learning most, what significance lifelong learning has on public administration and non-profit sector and compare its practical importance in the public administration and non-profit sector. A partial objective of the paper is to evaluate the financial situation before and after 2009 with respect to changes in lifelong learning of economically active citizens in selected institutions. The theoretical part was based on the study of documents, and the assessment from an economic impact point of view was based on a secondary analysis of the data. The research was carried out using the method of quantitative and qualitative data collection at two organisations of public administration and two organizations of non-profit sector.

Material and Methods

The public administration institutions were represented by Educational Institution and Job Centre in a selected region. With respect to the wish of the representatives of state institutions to maintain their anonymity, abbreviations will also be used for non-profit organisations – Association and Centre.

The carried out quantitative research was based on the above mentioned objectives which were processed into simple research issues: Workers in the organisations of public administration study more often. From an individual perspective, money is the main impulse for lifelong learning as well as the main obstacle, especially from the viewpoint of the organisation. Due to the impact of economic crises, financial means for learning are restricted and education events subsidised by means of ESF are preferred more frequently. Higher demands for workers' learning are placed on public administration employees. The field of economics is not a sought course topic.

For qualitative research the method of a semi-structured interview was used during which the managers of individual institutions where the research was carried out were interviewed. In such an interview, open, theoretically derived and confrontational questions were asked. It is also possible to ask arbitrary, additional questions (Disman, 2009). The questions concerned the running of the institutions and the education of workers within the institution (e.g. What motivates education and qualification in your institution – laws, internal regulations and the like?; Has the economic crisis had any impact on education in your institution? If yes, how and to what extent?; Which areas of education are most frequently sought after? ; Do you organize educational courses for your employees?; Is workers' education taken into account in their wages? and so on.) The outputs of the qualitative research were processed

by the method of synthesis where all data obtained from the research in the institution were unified in the final output.

Results

The research took place during 2011 following on-going courses and evaluation of training within the organisations. In the Educational Institution respondents received 70 questionnaires, 67 (95.72%) were returned. In the Job Centre 50 questionnaire were distributed, 46 (92%) were returned. In the Association the respondents received 21 questionnaires, 20 were returned (95.24%). In the Centre 25 questionnaires were distributed among the respondents, out of which 21 were returned (84%). Altogether 154 respondents participated in the research.

One of the first questions surveyed the participation of the respondents in educational events (Tab.1). The most frequently selected answer out of four offered answers was that their participation was optional and regular. The answer was selected by 48 (31.2%) respondents. The lowest number of respondents supported the option that their participation was obligatory and irregular. This answer was selected only by 27 (17.5%) of all respondents. Table 1 reveals that workers of non-profit organisations are more interested in studies than public administration workers.

PARTICIPATION	Centre (21)		Association (20)		Job Centre (46)		Educational Institution (67)		All (154)	
	n	%	n	%	n	%	n	%	n	%
Obligatory, regular	5	23.8	6	30.0	0	0.0	28	41.8	39	25.3
Obligatory irregular	2	9.5	2	10.0	21	45.7	2	3.0	27	17.5
Voluntary, regular	5	23.8	10	50.0	9	19.6	24	35.8	48	31.2
Voluntary, irregular	9	42.9	2	10.0	16	34.8	13	19.4	40	26.0

Tab. 1: Participation in seminars, courses, educational programmes

Whether greater demands are placed on the education of employees in the public sector or in non-profit organisations is shown in Table 2 (taking into account first two possible answers "compulsory regular" and "compulsory irregular"). The workers in non-profit organisations selected the possibility of "compulsory", "regular" and "compulsory regular" by 36.6%, the workers of public sector by 45.2%. Greater demands are placed on the employees of public sector; they are obliged to educate themselves by 8.6% more, and mandatorily.

PARTICIPATION	Centre (21)		Associa-tion (20)		Total (41)		Job Centre (46)		Educa-tional Institution (67)		Total (113)	
	Non-profit institutions						Public administration					
	n	%	n	%	n	%	n	%	n	%	n	%
Compulsory, regular	5	23.8	6	30.0	11	26.8	0	0.0	28	41.8	28	24.8
Compulsory, irregular	2	9.5	2	10.0	4	9.8	21	45.7	2	3.0	23	20.4
Voluntary, regular	5	23.8	10	50.0	15	36.6	9	19.6	24	35.8	33	29.2
Voluntary, irregular	9	42.9	2	10.0	11	26.8	16	34.8	13	19.4	29	25.6

Tab. 2: Demands for education in non-state[2] and state sector

The evaluation of the question whether the institution employer contributed financially to professionally educational events (Tab.3) was confirmed by 52 (33.8%) respondents who replied that in this respect their employer financially contributed to all workers. The employer contributed selectively only to 34 (22.1%) and exceptionally to 27 (17.5%) respondents. The employer did not financially contribute to anyone in case of 41 respondents (26.6 %). To conclude, in most cases the employer does contribute financially to educational events.

[2] The expression "non-state" is used in this text rather than "private" as it refers to non-profit institutions only.

CONTRIBUTION	Centre (21)		Associa-tion (20)		Job Centre (46)		Educational Institution (67)		All (154)	
	n	%	n	%	n	%	n	%	n	%
Yes, to everyone	7	33.3	15	75.0	26	56.5	4	6.0	52	33.8
Yes, selectively	5	23.8	4	20.0	8	17.,4	17	25.4	34	22.1
Exceptionally, selectively	5	23.8	1	5.0	3	6.5	18	26. 9	27	17.5
No, never and to no one	4	19.0	0	0.0	9	19.6	28	41.8	41	26.6

Tab. 3: Financial contribution of the institution to professionally educational events

The objective of the question was to find out the most frequent reason why the respondents began to study or why they studied (Tab.4). The respondents were able to select more than one offered answer. The most frequent reason why the respondents started to study or why they studied was higher qualification. This answer was indicated by 139 (90.3 %) respondents. It was also the most frequently selected answer even in individual institutions. The second most frequent reason was their interest in studies. This answer was selected by 114 (74.0%) respondents. The third most frequent reason for beginning the studies was the idea of a higher salary, which was answered by 112 (72.7%) respondents. On the contrary, the least frequent reason was improving the position, which was selected by 99

(64.3%) respondents. The reason being admired by others was chosen by 38 (24.7%) respondents only. This answer was the least frequently selected even in individual institutions. The table reveals that the highest number of respondents supported the possibility of increasing their qualification. Of total 154 respondents, 139 (90.3%) respondents regard the increase in their qualification as the most important reason for beginning the studies.

REASONS	Centre (21)		Associa-tion (20)		Job Centre (46)		Educa-tional Institution (67)		All (154)	
	n	%	n	%	n	%	n	%	n	%
Higher qualification	21	100.0	17	85.0	41	89.1	60	89.6	139	90.3
Interest in studies	18	85.7	14	70.0	27	58.7	55	82.1	114	74.0
Being admired by others	5	23.8	10	50.0	11	23.9	12	17.9	38	24.7
Improving position	13	61.9	13	65.0	28	60.9	45	67.2	99	64.3
Higher salary	16	76.2	14	70.0	34	73.9	48	71.6	112	72.7

Tab. 4: Reasons for learning

For the evaluation of the interest in learning with respect to the sectors (non-profit organisations and public administration institutions), the answers to question 4, namely "Interest in study and learning" were used. The table below (Tab. 5) contains the survey of answers to the above-mentioned question and the sum of the answers per individual respondents. From the table it is fairly obvious that there is a higher interest in studies among the workers of non-profit institutions, and that is by 3.6%. At first sight, this fact does not reveal any significant difference, nonetheless, it is necessary to stress that non-profit organisations are based on voluntary basis and almost all training is more or less voluntary (except for some compulsory training following certain legal regulations, especially when engaged in the area of social services).

	Centre (21)		Associa-tion (20)		Total (41)		Job Centre (46)		Educa-tional Institu-tion (67)		Total (113)	
	Non-profit organisations						Public administration					
	n	%	n	%	n	%	n	%	n	%	n	%
Interest in study and learning	18	85.7	14	70.0	32	76.2	27	58.7	55	82.1	82	72.6

Tab. 5: Interest in learning in non-state and state sector

Another question was related to the previous one because it investigated the reasons why the respondents did not begin to study (Tab.6). They could choose from seven answers and again they could indicate more than one answer. The most frequent reason why the respondent did not begin to study was the lack of finance. This answer was selected by 76 (49.4 %), which was almost half of all respondents. This answer was also the most frequently indicated answer even in individual institutions. The second most frequent reason was the impossibility to study while being employed, which was answered by 48 (31.2 %) respondents. The third most frequent reason was the fact

that the employer did not require it, which was answered by 47 (30.5%) respondents. The fourth position was occupied by the threat of failure in the studies. This was answered by 39 (25.3%) respondents. The fifth and sixth position was shared by two possibilities, the first that the employer did not assess learning positively and the second that the employees did not need to study. This was answered by 38 (24.7 %) respondents. No interest in education was the seventh possibility and it was indicated by 22 (14.3%) respondents. Table 6 reveals that the greatest reason for not studying was the lack of finance. Of total 154 respondents, 76 (49.4%) respondents regarded the lack of finance as the most important reason for not initiating the studies or no studies.

REASONS	Centre (21)		Association (20)		Job Centre (46)		Educational Institution (67)		All (154)	
	n	%	n	%	n	%	n	%	n	%
Lack of finance	7	33.3	9	45.0	22	47.8	38	56.7	76	49.4
No possibility to study while working	7	33.3	1	5.0	13	28.3	27	40.3	48	31.2
No interest in learning	4	19.0	0	0.0	5	10.9	13	19.4	22	14.3
Threat of failure	3	14.3	3	15.0	13	28.3	20	29.9	39	25.3
Not necessary at work	5	23.8	2	10	15	32.6	16	23.9	38	24.7
Not required by employer	5	23.8	3	15.0	23	50.0	16	23.9	47	30.5
Employer does not assess positively	3	14.3	1	5.0	18	39.1	16	23.9	38	24.7

Tab. 6: Reason for not taking part in learning

Table 7 contains the answers to the question which was finding out how many times a year the respondents took part in learning programmes. The respondents were given the choice of four answers; once, which was selected by 51 (33.1%), twice, which was selected by 32 (20.8%) and, last but not least, 62 (40.3%) respondents took part several times[3]. The last possible answer, never, was selected by 9 (5.8%) respondents only.

PARTICIPATION	Centre (21)		Association (20)		Job Centre (46)		Educational Institution. (67)		Total (154)	
	n	%	n	%	n	%	n	%	n	%
Once	5	23.8	1	5.0	30	65.2	16	22.4	51	33.1
Twice	4	19.0	4	20.0	11	23.9	13	19.4	32	20.8
Several times	12	57.1	15	75.0	5	10.9	30	44.8	62	40.3
Never	0	0.0	0	0.0	0	0.0	9	13.4	9	5.8

Tab. 7: Reasons for not participating in learning

Table 8 below presents the issue for the perspective of individual groups of respondents. The table (see Tab. 8) illustrates how often the institutions take part in educational events. There were 14.6% respondents from non-profit institutions taking part once, 19.5% twice and 65.9% several times. On average, there were 36.67% respondents taking part in some educational event. As regards public administration, there were 39.8% respondents taking part once, 21.2% twice and 31.0% several times. On

[3] More than twice.

average, there were 30.67% respondents participating in some educational event. The workers of non-profit institutions learn more often, which can be expected due to the nature of the need of non-profit organisations to be independent and viable.

PARTICIPATION	Centre (21)		Associa-tion (20)		Total (41)		Job Centre (46)		Educa-tional Institution (67)		Total (113)	
	Non-profit institutions						Public administration					
	n	%	n	%	n	%	n	%	n	%	n	%
Once	5	23.8	1	5.0	6	14.6	30	65.2	16	22.4	46	39.8
Twice	4	19.0	4	20.0	8	19.5	11	23.9	13	19.4	24	21.2
Several times	12	57.1	15	75.0	27	65.9	5	10.9	30	44.8	35	31.0
Never	0	0.0	0	0.0	0	0.0	0	0.0	9	13.4	9	8.0

Tab. 8: Frequency of learning with respect to non-state and state sector

Another question of the standardised questionnaire was finding out what topic of educational events the respondents preferred (Tab.9). They could choose from eight options and again they were able to select more than one answer. The most interesting area of educational event was considered the topic of communication, which was selected by 72 (46.8%) respondents. The second and third place was shared by two areas, law and creative activities. These two answers were selected by 42 (27.3%) respondents. 40 (26%) respondents were interested in other topics. The fifth and sixth place was occupied by languages, bullying and conflicts, the number of respondents was 39 (25.3%). The last but one place belonged to IT and ICT technologies, thanks to 31 (20.1%) respondents. The table shows that there was the least interest in economics.

TOPIC	Centre (21)		Associa-tion (20)		Job Centre (46)		Education-al Institu-tion (67)		All (154)	
	n	%	n	%	n	%	n	%	n	%
Law	3	14.3	4	20.0	26	56.5	10	14.9	42	27.3
Economics	4	19.0	0	0.0	8	17.4	11	16.4	23	14.9
IT, ICT technologies	1	14.3	1	5.0	12	26.1	15	22.4	31	20.1
Languages	4	19.0	5	25.0	9	19.6	21	31.3	39	25.3
Creative activities	5	23.8	9	45.5	2	4.3	26	38.8	42	27.3
Communication	13	61.,9	11	55.0	21	45.7	27	40.3	72	46.8
Bullying, conflicts	8	38.1	7	35.0	11	23.9	13	19.4	39	25.3
Other	7	33.3	15	75.0	3	6.5	15	22.4	40	26.0

Tab. 9: Course topic preference

The qualitative research in the institutions of public administration and in non-profit organisations concentrated on financing the educational courses in terms of financial crisis. The managers of all four institutions were interviewed. Their answers were as follows:

The ůinterview with the manager of the Centre revealed that learning within their institution was not influenced by the crisis

because as a non-profit organisation they did not take part in educational events and courses which were not held for free. As the case may be, they had put aside a minimal number of financial means; however, from 9% it concerned free-of-charge learning. The economic crisis had rather influenced the height of sponsorship gifts from organisations that supported them because it affected their budgets.

From the interview with the manager of the Association it follows that the economic crisis affected very much not only the education itself but also other activities. Their contributions were rather reduced which reflected in the reorganisation of their activities. Unfortunately, the situation still prevails.

According to the manager of the Job centre, the economic crisis had of course affected even them and not only in the area of education. They had to dismiss several colleagues. In the area of education they appealed to the employees to find a course that would be more effective and less expensive. First, of course, they would have to look among the offered events endowed by ESF. In many courses, they used the services of their own lecturers, especially in managerial and language training.

Last but not least, the interview with the manager of the Educational institution revealed that educating their workers went hand in hand with self-financing of the workplace – the work place had to make money for it or, if possible, use individual financial activity of the employee. This institution would not contribute to the training of this department staff.

Based on the above mentioned answers it is apparent that 3 out of 4 addressed managers confirmed that the economic crisis had affected the staff training in their institution.

Discussion

From the carried out survey it can be assumed that the respondents of both groups of training studied voluntarily and regularly. In both cases this was supported by more than 31% respondents. The reason may also be explained by certain consciousness and effort to achieve competitive advantages because, with the impact of the economic crisis, main work positions are cancelled or combined together or, and that is the worst case, the company simply perishes. Nearly no one can be sure about his or her job and therefore further training is vital. There exist certain preconditions that there will be an increased appeal on lifelong learning, and not only due to the fact that it is one of the EU objectives how to assimilate EU member states. One of the possible ways how to delete significant differences on the fields of education of EU member states citizens is an operational programme. However, according to the last news and information from the media, competitiveness training has rather become a business for certain political parties and economic bodies. The training remains only a cover for their enrichment from the sources of ESF.

Nevertheless, a statistical survey from 2010 revealed that it is not only thanks to the above mentioned ESF endowments that the CR lifelong learning is not able to become competitive and comparable with other EU member states. “The Czech Republic is approaching the situation in which there will soon co-exist side by side weak years of young people with a high percentage of university graduates and strong years with a profound under-average university educated people. The question of increasing the qualification of today’s thirty or forty –year old, either by formal or informal studies, is becoming a significant factor affecting an economic and social situation of the citizens”. (Czech Statistical Office, Lifelong learning in the CR lags way

behind the European Union http://www.czso.cz). In 2011, in agreement with the Act No 89/1995 Coll., on state statistical service, as amended in later regulations, the Czech Statistical Office held a tender on adult learning in the CR – AES Adult Learning 2011, following a pilot survey from 2007 – 2008. The idea of the survey was to map the situation in adult learning in the CR with focus on the participation of individuals in different types of training. Thanks to international nature of the survey, it will be possible to compare the situation in the CR with a situation worldwide once the survey is completed.

The employers of business enterprises and private sphere invest in fewer financial means determined for training. The reasons may be of economic nature (caused by the economic crisis). However, even they should realize that the investments in their staff training will return in the form of higher competitiveness, work productivity growth and improved image of the company. Lifelong learning and "trained human capital" have a considerable impact on one's position on the labour market.

In her study, Arapovics (2008) offers a complete survey of adult training in non-profit organisations. The study provides a lot of data about organisations registered in the education registry besides institutional accredited training. The survey was carried out in 139 non-profit educational organisations which differed in their character from budget and business sector. It takes into account two basic types of training in non-profit organisations, with respect to the subject area of the course (civil values, i.e. voluntary courses, and courses of economic competition, i.e. economic, financial, public relations and fundraising courses).

The training of employees in non-profit sector is modified very generally in the Act No. 262/2006 Coll., Labour Code. It does not concern regulation specifics for this area only, but the regulation generally intended for all employees and employers. If we want to find out how training in non-profit sector works, we can do so only on the basis of internal regulations of individual organisations.

There is a gradual development of Quality Standards in individual areas which are beginning to deal with training in various fields. The system of staff training in non-profit sector can vary with respect to the provider of social services. Act No 108/2006 Coll., on social services, as amended in later regulations, determines a minimum range of further compulsory training. Based on § 111 of this act, the employer is obligated to provide his or her social worker with further training in his or her qualification in the range of at least 24 hours per calendar year. The training may be provided by universities or schools of higher education, participation in accredited courses, professional training in social service institutions or participation in training events (6, § 111).

Moreover, in some specialized or professional organisations there exist associations imposing minimum range of training in specific courses.

Since there is no unified legal regulation which would prescribe specific compulsory training for the staff of the non-profit sector, non-profit organisations do not automatically receive endowments for staff training. Finding sources for training thus remains on the shoulders of the employee or volunteer who, depending on his or her fundraising abilities, tries to find means for staff training.

Conclusion

A principal reason for providing staff training is an attempt for higher or better position and higher qualification. This is however very often prevented by the lack of finance. How can workers increase their qualification and take part in lifelong learning if their financial situation does not allow for it? Based on the above mentioned information, it is clear that there exists a tight connection between economic crisis, economic prosperity and lifelong learning. These aspects are all related and it is therefore necessary for the CR to progressively increase the level of education by means of modern, quality and flexible system of educational and professional training. This does not regard professional qualification. It is necessary to concentrate on an overall ability of the citizens to adapt to a current dynamic development and worldwide globalization. This adaptation brings demands for language skills and ability to work with information, information technologies and ability to orientate in different cultural environment. For increasing competitiveness and applicability lifelong learning is vital.

Learning in non-profit sector is conditioned by legislation; however, it is not strongly connected with a career growth and therefore the learning of workers is not taken into account financially. In public sector, learning can differ with respect to the nature of an institution, it is adjusted by the legislation and the learning of workers is taken into account financially. The obligation proceeding from legislative regulations must be respected; breaking it can result in financial penalty of the worker, reducing his or her bonuses or personal remuneration. The learning of workers for non-profit sector has its legislative regulations, too. For this purpose there are held various types of educational events initiated by the employee who, based on the survey, contributes more than the employee of the respondents from public administration. Lifelong learning definitely has a greater significance in non-profit sector whose employees or, as the case may be, volunteers engaged in non-profit organisations participate in learning events more twice or even several times a year than the public administration workers (cf. research findings in Tab. 8).

Especially modern days give meaning to lifelong learning. There is a constant, revolutionary progress which needs to be followed. People are under the pressure caused by society, employees and, last but not least, family members.

Lifelong learning can be regarded as an efficient tool contributing to the improvement of economic conditions, it can effectively support competitiveness, regional development, the growth of economic dynamics, and it can support higher employment of inhabitants and boost their mobility. However, in the Czech Republic it still remains on a very low level.

The area of lifelong learning is given a considerable attention, not only by professional society but its importance is also understood by the EU. The reason for this can be explained by an indisputable significance of lifelong learning for socio-economic development of the society.

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VALIDATION OF THE SERVICEABILITY OF THE MANUFACTURING SYSTEM USING SIMULATION

Ivan Lazár, Jozef Husár

Technical University in Kosice
ivan.lazar@tuke.sk

Abstract

This article discusses the creation and use of known algorithms in production that uses a flow-shop system to monitor and verify its operability. It also describes the input data, which must be further opportunities for decision entered into the system. In the next section are described in detail the different parts of this procedure. Than it describes the sequential problems that are not yet at a practical level, few addressed, but thus methods shorten the processing time. The conclusion focuses on the validation of the serviceability of the manufacturing system using knowledge mentioned and their embedding and verification by simulation.

Key Words

Flow-shop system, algorithm, sequential problems, simulation model, serviceability, wastage rate

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Introduction

With the advent of just-in-time manufacturing philosophy which maintains a limited in-process inventory, the flow-shop scheduling problem with minimum make-span and optimization approaches to minimize manufacturing cost started to be intensively studied (Modrak and Moskvich, 2011). Flow-shop scheduling problems present an important class of sequencing problems in the field of production planning. Solving this problem means finding a permutation of jobs to be processed sequentially on a number of machines under the restriction that the processing of each job has to be with respect to the objective of minimizing the total processing time i.e. flow-time (Sule, 1982).The permutation flow-shop scheduling problem (PFSP) is often designed by the symbols $n|m|P|C_{max}$, where n jobs have to be processed on m machines in the same order. The processing of each job on each machine is an operation which requires the exclusive use of the machine for an uninterrupted duration called the processing time. *"P"* indicates that only permutation schedules are considered, where the order in which each machine processes the jobs is identical for all machines. Hence a schedule is uniquely represented by a permutation of jobs. The common objective is to find a schedule that minimizes the makespan C_{max}, the time at which the last job is completed on the last machine. In a statistical review of flow-shop scheduling research, concluded that there is lack of relevance to practice for the overall majority of research in this field. They emphasize "that flow-shop scheduling research is in dire need of paradigm shift to enhance its probability of ever becoming a tool for the practice (Bucki and Chramcov, 2011).

Complexity theory provides a mathematical framework, in which computational problems are studied so that they can be classified as "easy" or "hard" (Brucker, 1998). For the pure flow shop problem, there are generally $(n!)^m$ different sequencing alternatives. However, for the PFSP the search space is reduced to $n!$ because it considers the same order of processing all the jobs in all machines. Consequentially, the n-job m-machine PFSPs belong to the class of NP-hard problems (Lenstra, 1997) Thus, in a PFSP, the computational requirements for obtaining an optimal solution increase exponentially as problem size increases. Nevertheless, it is well-known that the case of the PFSP composed of two machines (F2 $||Cmax$), could be easily solved using Johnson's rule which generates an optimal schedule in $O(n*log(n))$ time (Johnson, 1954 and Carlier, 1996). However, for $m \geq 3$, the problem is shown to be strongly NP-hard (Garey et. al., 1976).

Complexity of manufacturing system, wastage rate and serviceability of this system are some of the most important concepts in theory of production systems in practical solutions as well as in theoretical modeling. To create a universal tool for Flow-shop production system is necessary to take into account several basic input parameters. In order to achieve the required parameters, it is necessary to maintaining a chronology for the optimization, and the next steps:

- analyze the raw data and analyze the production program (ABC analysis and PQ diagrams),
- perform a detailed analysis of the current layout,
- calculate the capacity of the functional elements of production systems,,
- apply the segmentation of production - design of groups of components, or choose representatives (PFA analysis, cluster analysis, ROCA, DCA algorithm and others),
- propose an alternative solution,
- select a suitable simulation program,

- verify the simulation model with number of changes and input values,
- verify the operability of system.

General algorithm development of production lines with the principles of flow – shop

Procedure written or graphic, which describes the same problem solving we can simply call the algorithm. Each algorithm is composed of individual steps that lead either to the next step or gradually returns to predetermined level solutions. (Anu, 1997)

Materials and Methods

Simulation is becoming increasingly used method for testing and monitoring of various systems and phenomena. Simulation can be used to investigate the causes of various disorders and can be used for the prevention of these disorders and accidents.

This article is divided in several parts. In first part we have created a unique graphic algorithm, which serves as a map for designing and creating a simulation model (created to verify operability of PS (*PS-production system*)). This simulation model can be defined in several ways:

based on experience,

- based on real PS,
- based on mathematical model
- based on pervious simulation with the change of domain. (Knapcikova et al,2011)

In next section we conceived the design organization chart of the manufacturing process. This chart is divided in 5 phases (*from input data and quantities to profit and cost*). Third part consists of

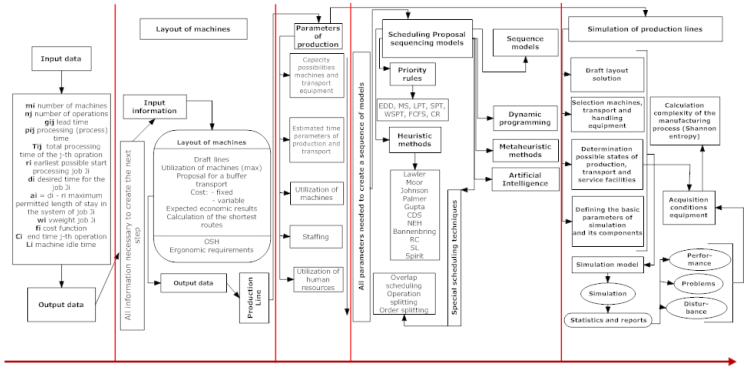


Figure 1: Flow diagram of simulation model (Gupta, 1971), (Husár and Lazár, 2011).

Input parameters

- w_i weight tasks J_i. It expresses its relative importance,
- f_i cost function – non-decreasing real function, that metering costs $f_i(t)$, paid to, the role J_i was completed in time t. In general g_i; p_i; or. p_{ij} and w_i are integers,
- C_i end time *j-th* operation on the *i-th* machine (possible start *j+1-th* operation on the *i-th* machine),
- L_i downtime of the machine to start *j+1-th* operation
- m_i number of machines $m_i = \{S_1, S_2, S_3, ..., S_i\}$ or $\{M_1, M_2, M_3, ..., M_i\}$, where j=1, 2,..., n and i=1, 2,..., m
- n_j number of operations $n_j = \{O_1, O_2, O_3, ..., O_i\}$ or $\{J_1, J_2, J_3, ..., J_i\}$,
- g_{ij} lead time for processing *j-th* operation on the *i-th* machine,
- p_{ij} processing (process) time *j-th* operation on the *i-th* machine,

- T_{ij} total processing time *j-th* operation on the *i-th* machine ,
- r_i earliest possible start of processing tasks J_i. This statement can be viewed as a time entry task J_i to system (release date),
- d_i required time of completion of tasks J_i,
- $a_i = d_i - r_i$ maximum permissible length of stay roles J_i in system. (Lazár and Husár, 2011)

The result of projecting the spatial structure of the production process is plant layout and of workplaces, so the actual technological project. A simplified diagram (model) design organization of the manufacturing process is on figure 2. The design here is a gradual work ongoing in phases.

Steps in the simulation model

The application of simulation involves specific steps in order for the simulation study to be successful. Regardless of the type of problem and the objective of the study, the process by which the simulation is performed remains constant. The following briefly describes the basic steps in the simulation process by (Husár and Lazár, 2011);

STEP 1 Identify and formulate the problem.

Enumerate problems with an existing system. Produce requirements for proposed system. Select the bounds of the system, the problem or a part thereof, to be studied. Define overall objective of the study and a few specific issues to be addressed.

Step 2 Collect and process real system data.

Collect data on system specifications, input variables, as well as performance of the existing system.

Step 3 Perform verification and validation on the model.

Develop schematics and network diagrams of the system and translate these conceptual models to simulation software acceptable form. Verify that the simulation model executes as intended. Compare the model's performance under known conditions with the performance of the real system. The aim of verification and validation is to ensure that the model is sufficiently accurate.

Step 4 Document model for future use.

Document objectives, assumptions and input variables in detail. Variables of a simulation model so that we may observe and identify the reasons for changes in the performance measures.

Step 5 Select appropriate experimental design.

Select a performance measure, a few input variables that are likely to influence it, and the levels of each input variable. Document the experimental design.

Step 6 Establish experimental conditions for runs.

Simulation experiment is a test or a series of test in which meaningful changes are made to the input variables of a simulation model. First, address the question of obtaining accurate information and the most information from each run. Then, determine if the system is stationary (performance measure does not change over time) or non-stationary (performance measure changes over time).

Step 7 Perform simulation run.

The main model and the other scenarios based on experiment designs are run to get the output and results to compare.

Simulation needs to be run with many replications which is, replication is defined as executing the same model a numbers of times, but with different random number in each runs.

Step 8 Implement the model in real setting.

The original system and the modification described were studied.

Step 9 Recommend further course of action.

This may include further experiments to increase the precision and reduce the bias of estimators, to perform sensitivity analyses, etc. (Dlouhy, 2007)

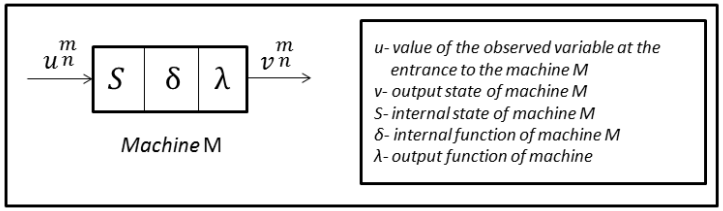


Figure 2 Mathematical model of one machine production

The simulation programs allow us to predict a variety of conflict situations, that would businesses have a lot of money and thanks to the fact that the entire of production process for our simulation program takes only a few minutes. With the program can produce a variety of statistics, graphs and reports that are used to detect bottlenecks and places, where the likelihood of malfunction of the real process.

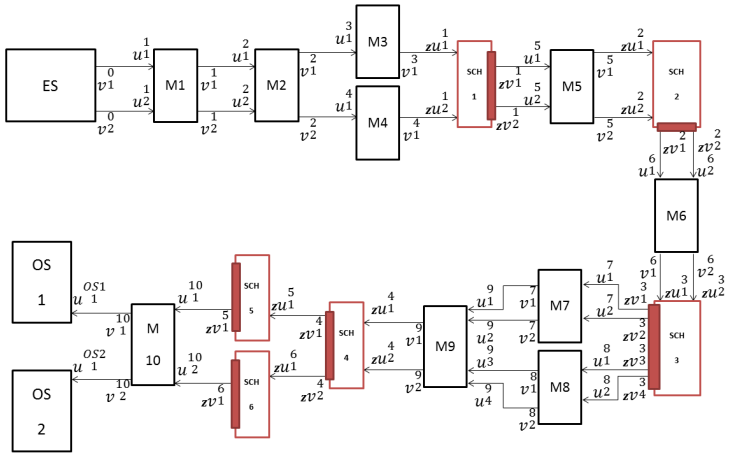


Figure 3: Mathematical model of simulation I.

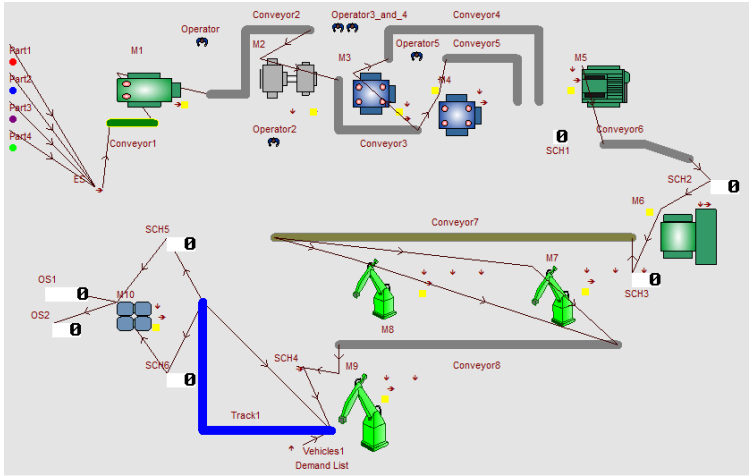


Figure 4: Simulation I field in Witness.

Figures 3 and 4 graphically illustrate the simulation I on Witness software. Figure 3 shows a mathematical model. This model describes all inputs and outputs that operate on different machines or buffers. Figure 4 describes the simulation field of Witness, which illustrates mentioned mathematical model. This simulation focuses on the states of machines and the failure rate after 8 hours shift. Graphical representation of states of machines, conveyor and parts are on the Figure 7 to Figure 12 below.

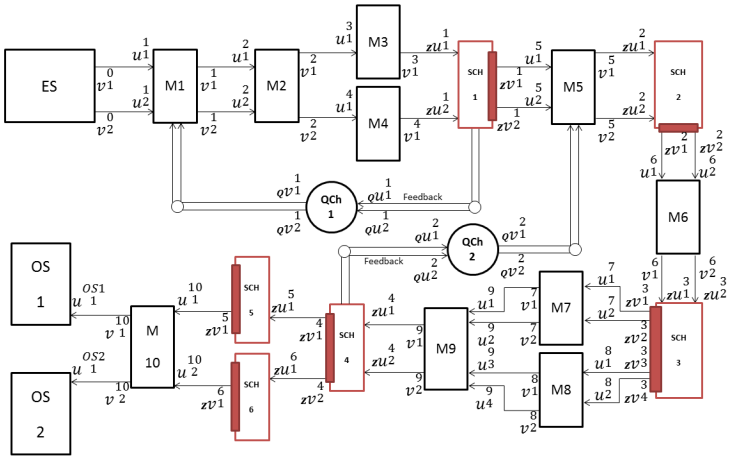


Figure 5: Mathematical model of simulation II.

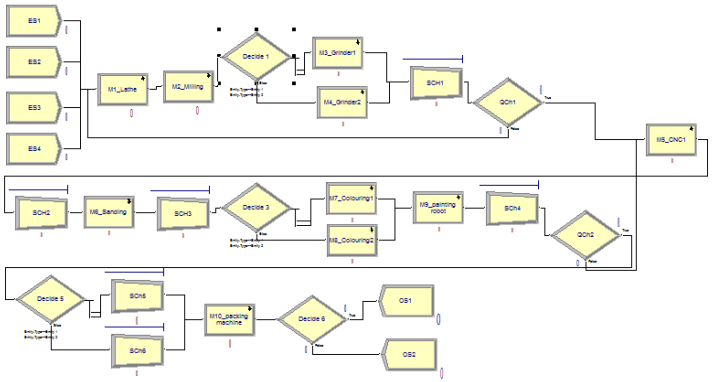


Figure 6: Simulation II field in ARENA.

Results

Figures 5 and 6 graphically illustrate the simulation II on Arena software. Figure 5 shows a mathematical model. This model describes all inputs and outputs that operate on different machines or buffers. Figure 6 describes the simulation field of Arena, which illustrates mentioned mathematical model. This simulation focuses on the error rate during 8 hours shift.

State of M1	Unfastening
State of M2	Setup
State of M3	Grinding
State_of_M4	Unfastening
State of M5	Machining
State of M6	Loading
State of M7	Colour insert
State of M8	Dry Cleaning
State of M9	Painting
State_of_M10	Transfer to storage

Figure 7: Running machines states.

Figure 8: Process Performance Pie Chart after one part finishing.

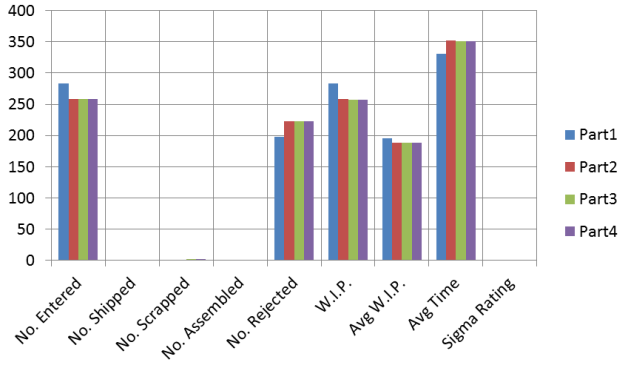


Figure 9: Part Statistics. Report by On Shift Time.

Name	Part 1	Part 2	Part 3	Part 3
No. Entered	283	258	258	258
No. Shipped	0	0	0	0
No. Scrapped	0	0	1	1
No. Assembled	0	0	0	0
No. Rejected	198	223	223	223
W.I.P.	283	258	257	257
Avg W.I.P.	195.17	188.98	188.44	188.40
Avg Time	331.26	351.83	350.83	350.75
Sigma Rating	0.00	0.00	0.00	0.00

Table 1: Part statistics after 8 hours shift.

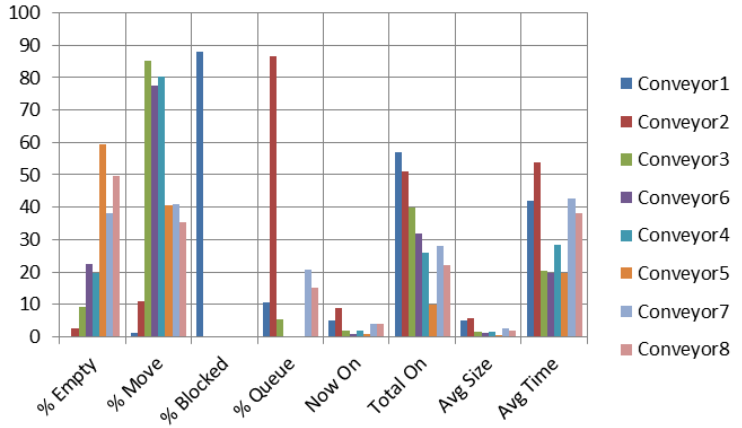


Figure 10: Conveyor Statistics. Report by On Shift Time.

Name	% Empty	% Move	% Blocked	% Queue	Now On	Total On	Avg Size	Avg Time
Conveyor1	0.00	1.25	88.13	10.62	5	57	4.98	41.96
Conveyor2	2.50	10.99	0.00	86.51	9	51	5.71	53.82
Conveyor3	9.37	85.22	0.00	5.41	2	40	1.67	20.4
Conveyor6	22.48	77.52	0.00	0.00	1	32	1.30	19.59
Conveyor4	19.78	80.22	0.00	0.00	2	26	1.53	28.24
Conveyor5	59.33	40.67	0.00	0.00	1	10	0.41	19.53
Conveyor7	38.31	40.87	0.00	20.82	4	28	2.48	42.51
Conveyor8	49.55	35.46	0.00	14.99	4	22	1.75	38.29

Table 2: Conveyor statistics after 8 hours shift.

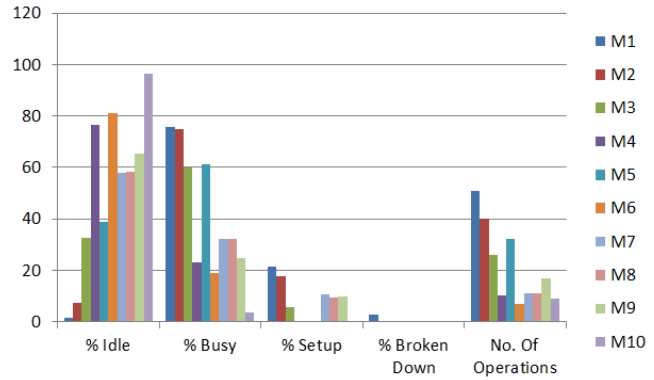


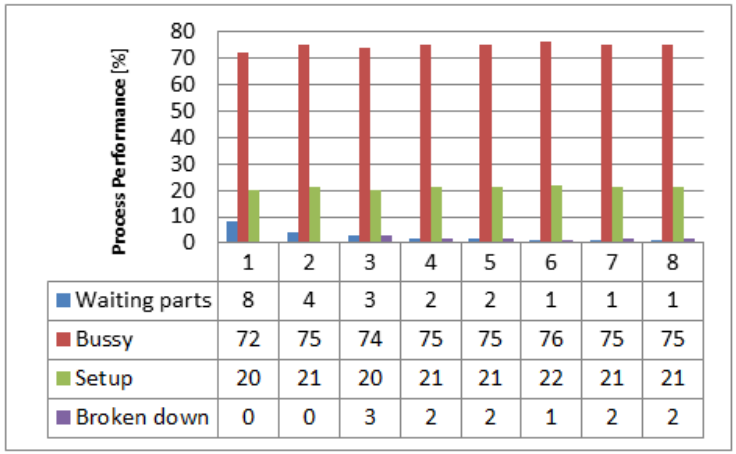
Figure 11: Machine Statistics. Report by On Shift Time.

The figure shows that the most broken down machine was machine M1 than machines M2 and M3. Most idle machine was machine M10 and it was more than 96% and on the other side the less idle machine was M1 it was less than 2%.

Name	% Idle	% Busy	% Setup	% Broken Down	No. Of Operations
M1	1.4	75.64	21.24	2.8	51
M2	7.49	75.02	17.7	0.42	40
M3	32.48	60.03	5.62	0.42	26
M4	76.68	22.90	0.00	0.00	10
M5	38.83	61.17	0.00	0.00	32
M6	81.05	18.95	0.00	0.00	7
M7	57.88	32.06	10.6	0.00	11
M8	58.50	32.06	9.44	0.00	11
M9	65.37	24.84	9.78	0.00	17
M10	96.25	3.75	0.00	0.00	9

Table 3: Machine statistics after 8 hours shift.

On Figure 12 are shown states of machines M1 to M10 every hour during 8 hours shift on the percentage basis. We can see that the machines were the most time in state BUSSY. The average value of the state was 74,625%.



	1	2	3	4	5	6	7	8
Waiting parts	8	4	3	2	2	1	1	1
Bussy	72	75	74	75	75	76	75	75
Setup	20	21	20	21	21	22	21	21
Broken down	0	0	3	2	2	1	2	2

Figure 12: Process Performance on a percentage basis

Nine parts were completed after 8-hour shift. Seven finished parts were waiting to be wrapped on machine M10. Twentyeight parts were waiting to be coloured and painted. Time after passing four parts (1 part from 1 type) was 620 min. From this time was less than 20% machining time and more than 80% shipping time. In the next steps we describe the simulation II in the ARENA.

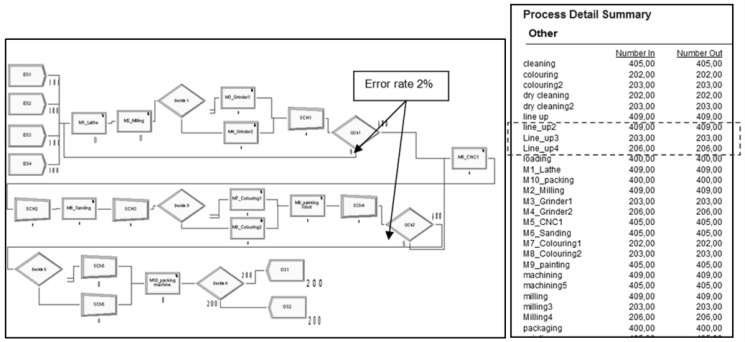


Figure 13: Results of errors rate 2% for 100 pieces of each component

In Figure 13 we can see a simulation of the manufacturing process in the ARENA programme. The simulation assign to the insertion of position to control on QCh1 QCh2 which is set to 2% error rate. As input data were put to the simulation 4 units of 100 pieces, where the error rate of 2% on the QCh1were 9 error rate and on the QCh2 were 5 error rate. After running the simulation it is possible to generate reports in time and number form, rate units, utilization of machines, input and output units in machines. From the machine Line_up 3 (on the left side) is seen that the error was 9 and in entities Nr. 1, 2 was 3 errors rate. From a a machine Line_up fourth arising that in entities 3 and 4 were 6 errors.

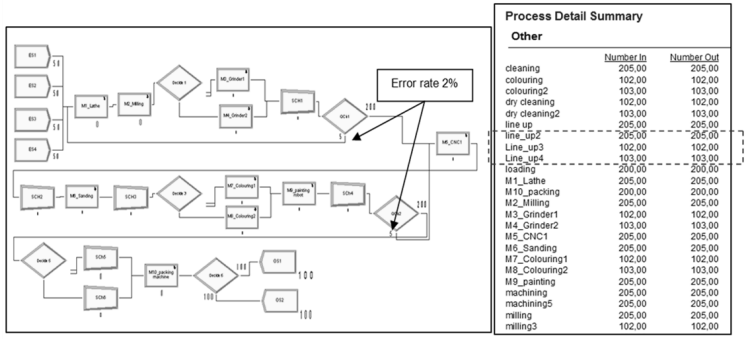


Figure 14: Results of errors rate 2% for 50 pieces of each component

In Figure 14 is presented the simulation 4 units of 50 pieces with 2% error rate. On the position QCh1 were 5 errors units and on the position QCh2 was errors units. On the left side (Machine Line_up 3) is seen that the error was 5 errors and entities Nr.1, 2 was incorrect 2 entities. From the machine Line_up fourth is to seen entities Nr. 3 and 4, from these entities were 3 errors. The simulation can be changed to a percentage of rejected setting transitoriness of 80% and 20% will rejected up to 99% where the rate is 1% of rejected.

Conclusion

The principle of line production is in today's modern and extremely rapid time used in most businesses, regardless of orientation. In this article we describe the main problems that arise in planning and management of such production. We have also compared different heuristic methods that are used for production scheduling, and we recommend the most appropriate method in our specified case. At the end of the article, we propose a unique graphical algorithm that describes

the steps and options in the case managing the line production. It can be used for research and educational purposes. This algorithm will be enriched in next publications for more options and choices.

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