

POSSIBLE USES OF COMPUTER SYSTEMS IN UNIVERSITY TRAINING OF IT PROFESSIONALS

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Abstract. *In this paper, learning and knowledge control systems developed by the Faculty of Computer Science and Information Technology of the Riga Technical University are described. These systems are used in teaching various subjects on different study programs and specialties. The paper also presents results of use of computer systems in student self-study and self-control. Students could freely choose, whether or not to use these systems during their studies. We focused on two scenarios of non-compulsory use of computer systems, namely with a motivating system or without one. In both cases students actively used computer systems for self-control and self-study. Our research shows that using computer systems for both knowledge control and study (as opposed to knowledge control alone) increased knowledge level of all students, regardless of their overall performance.*

Keywords: *education, knowledge control, student performance, self-study, self-control.*

Introduction

Nowadays, due to the increasing pace of scientific and technical progress, requirements to knowledge and skills of modern specialists continuously grow. One of the most important aspects of any educational activity is the system of knowledge quality control. However, the discrepancy between the capabilities of traditional teaching methods and the amount of actual knowledge that modern society demands from graduates of educational institutions indicates a problem in the system of modern higher education. Therefore, the issues of computer training and knowledge control are of interest for many researchers, in the field of both education and information technologies (Gütl et al., 2011) (Golitsyna, 2012) (Lau et al., 2011) (Manako & Sinita, 2012).

Unfortunately, although technologies of computer education have significantly progressed in comparison with early 1990s (with virtual reality, multimedia, and remote internet access being used instead of former local networks of personal computers), global problems in this field stay the same. These problems were identified already in the late 1980s in a series of monographs, to which Riga Technical University (RTU) scholars L. P. Leontiev, L. A. Rastrigin, L. V. Nicetsky, L. V. Zaitseva, L. P. Novitsky and others contributed (Rastrigin & Erenshtein, 1986, Nicetsky, 1977, Zaitseva et al., 1989).

Currently there exist many international conferences, both scientific and scientifically methodical, (IEEE, ICALT, IADIS e-Learning, IASTED CATE and others), as well as electronic journals (Journal of Educational Technology & Society, 2017, The Electronic Journal „International Academy, Research, and Industry Association, 2017, The Electronic Journal of e-Learning, 2017), that focus on issues in computer education and knowledge control.

In addition to that, higher education of today poses high demands to the way students organize their individual studies. Organization of students' individual studies to a great extent defines the overall quality of learning. Self-study skills acquire relevance as an essential factor in the development of general competencies (Klizaitė & Arlauskienė, 2015). This lets one put forth a hypothesis that computer education systems furnished with appropriate technology can be used with high efficiency in solving such tasks.

In the study process at RTU, computer systems providing different methods of automatized teaching and training of IT professionals (acquisition of reference information, distance learning, exercises and other means of knowledge control) are also employed. These systems are also used in shaping skills necessary for individual studies.

In this paper, we use methods of mathematical statistics in order to demonstrate that use of the mentioned systems of computer learning and knowledge control indeed motivates students to pursue self-learning and increases performance of future IT-specialists.

Research Materials and Methods

The following systems have been developed and are now in use at the Faculty of Computer Science and Informational Technology:

- Learning Management System (LMS);
- Intelligent knowledge assessment system (IKAS);
- Computer-based system ORTUS.

Teaching and student knowledge control is performed using these systems in many subjects, e. g. “Data structures”, “Programming Languages”, “Technologies

of Software Development”, “Metrology and Planning of Software”, “Basics of Artificial Intelligence”, “System Theory Methods” and others.

For this paper, we have chosen two subjects. “Data Structures” is a compulsory course taught during the second term in the first year, while the course “Technologies of Software Development” is taught during the sixth semester in the third year.

Thus, the first group comprises 67 students of the Computer Systems study program. The second group comprises three specialties: Computer systems (134 students), Information Technology (116 students) and Automation and Computer Equipment (64 students)

Statistical analysis of data was carried out using the Statistica 8.0 software for Windows. The interconnection of parameters was assessed based on the Spearman’s nonparametrical coefficient (Glantz, 1998). To assess the validity of differences among the groups one actor dispersion analysis (ANOVA) was used with subsequent a posteriori analysis according to the Turkey method for unequal groups (Tukey HSD for unequal N)¹.

Computer Systems in Study Process

IKAS is an intellectual system of knowledge control that has the form of a web application. It focuses on assessing students’ structural knowledge. It was developed in 2005 and described in many publications (Grundspenkis & Anohina, 2009, Prokofjeva et al., 2013). The main tasks of the system are: a) assisting students in self-assessment of their structural knowledge and b) supporting teachers in enhancing study courses based on systematic analysis and evaluation of students’ knowledge structure.

IKAS supports three categories of users: administrator, teacher, and student. The system has six tasks of different complexity. The use of the system is based on interpreting the values of parameters available in the student model. The student model supports four types of operation adaptation in IKAS: selection of initial level of complexity of the task on the first stage of its evaluation, its change on the further stages of evaluation, set-up and modification of priorities of types of explanation concepts (feedback). More than 20 courses have been developed in IKAS: “Basics of Artificial Intelligence”, “System Theory Methods”, “Discreet Structures in Computer Science” etc. Results of use of this system are described in the following work (Anohina-Naumeca et al., 2011).

The ORTUS computer system is available to all RTU students and has been used in the study process since 2008 (Zaiceva & Prokofjeva, 2012). In this system the teacher can create a test, set the time and place of its competition, set the

¹ <http://www.statsoft.ru/home/textbook/modules/stanman.html>

number of attempts to complete the test. Thus, the test can be either a control work (one attempt) and take place in class, or an exercise (more than one attempt) completed remotely. It is possible to create tests from different categories of questions of similar type (10 question types are realized in ORTUS), considering their complexity, i. e. to assign more points to questions of higher complexity. All question types presuppose comments. The only drawback of the ORTUS environment is use of just one knowledge control method, namely, “random sampling”.

Currently 13 computer courses are realized in the ORTUS system for the subjects “Programming Languages”, “Data Structures”, “PHP Language in Development of Web Applications” etc. Such digitization of courses, according to all the teachers who have used ORTUS, helps to conduct knowledge control of different types and consider students’ performance at the exam. Thus, in the subject “Data Structures” electronic courses “Pointers, Arrays and Strings” and “Lists, Stacks and Queues” ensure border knowledge control, as they let evaluate level of student knowledge on separate themes and incorporate the control work results into the outcome of the final exam. The subject “PHP Language in Development of Web Applications” includes the control work “HTML and CCS” that performs initial control letting assess the knowledge level of the students before they get to study PHP. All study courses within the subject “Programming Languages” must be completed remotely and are also taken into account when grading student performance at the exam.

The LMS system was developed by a professional group “Technology of software development” in 2004 (Zaitseva & Bule, 2008, Zaiceva et al., 2017). The system supports two modes directly related to knowledge control: random choice of tasks and/or questions for control and teaching. Both can also be used for self-control. The random choice mode implements non-adaptive method of control. In this case the number of questions for knowledge control in a students’ group is set by the teacher, who also specifies the number of tasks of different complexity (maximum, medium, minimum) to be included in each set of control questions. The teacher also defines the type of comment students get in response to their answers: short (correct, imprecise, incorrect) or extended, including the explanation of mistakes. In case of self-control the student herself sets these parameters. The method implemented by teaching mode depends on choice made: it can be either non-adaptive (involving a fixed sequence), where the student completes all or a selected number of control tasks, or partly adaptive (considering students’ answers), where the number of tasks offered to the student depends on how well they are completed. In this mode, it is also possible to set the type of comment. On completing control the student get a grade that takes into account not only correctness of the answers, but also their value (maximum, medium, minimum) and complexity.

Currently LMS includes 8 learning programs in subjects “Software Development Technology”, “Metrology and Planning of Software”, “Instruments and Environments of Software Development”, that can be used in all modes described above, as well as one electronic course for college students in “Programming Languages”. During the initial stage of LMS use in the years 2004–2006 students could use the courses available in the system for self-control, training and/or learning. Starting with 2007, student knowledge control in the courses is obligatory and is usually performed during practical classes. Each student is offered 6 to 8 tasks for control. Within 2 days after taking the control work the student can take it again in order to improve her result. In this case the work is graded by the teacher. Other modes of the system can be used by students at any time (Zaitseva, 2008).

In what follows, the LMS and ORTUS systems get assessed from the point of view of their influence on student performance as the result of non-compulsory use.

Non-compulsory use of the LMS computer system for self-study and self-control of knowledge: effects on student performance

The role of individual studies is constantly growing in educational process. This explains the relevance of the question of organization of individual work of students and development of corresponding skills (Rupšienė & Mažionienė., 2011). Computer learning systems can foster this process on the condition that their use is optimized for such tasks. The first thing to be determined is whether the students will employ computer systems of learning and knowledge control if their use will not be declared compulsory. The question regarding the motivation to non-compulsory self-control is also of importance.

In the research presented here influence of computer-based systems of learning and knowledge control on student performance was analyzed, with special focus on the question: whether use of computer-based for self-learning and self-control facilitates task solving in practical works? To research this question third year students were offered to freely attend test classes in “Software Development Technology”.

In the course of a semester students could voluntarily employ the LMS computer-based learning and knowledge-control system while completing practical works. The analysis of the collected data revealed:

- statistically significant ($p < 0,05$) correlation between the average laboratory class grade and attendance at test classes (0 to 4), Spearman’s correlation coefficient 0,57;

- statistically significant ($p < 0,05$) correlation between the average laboratory class grade and the average test work grade, Spearman's correlation coefficient 0,47.

Using ANOVA, the interconnection between attendance at test classes and the average score for laboratory works, exam grades and total rating of student performance (Fig. 1-3).

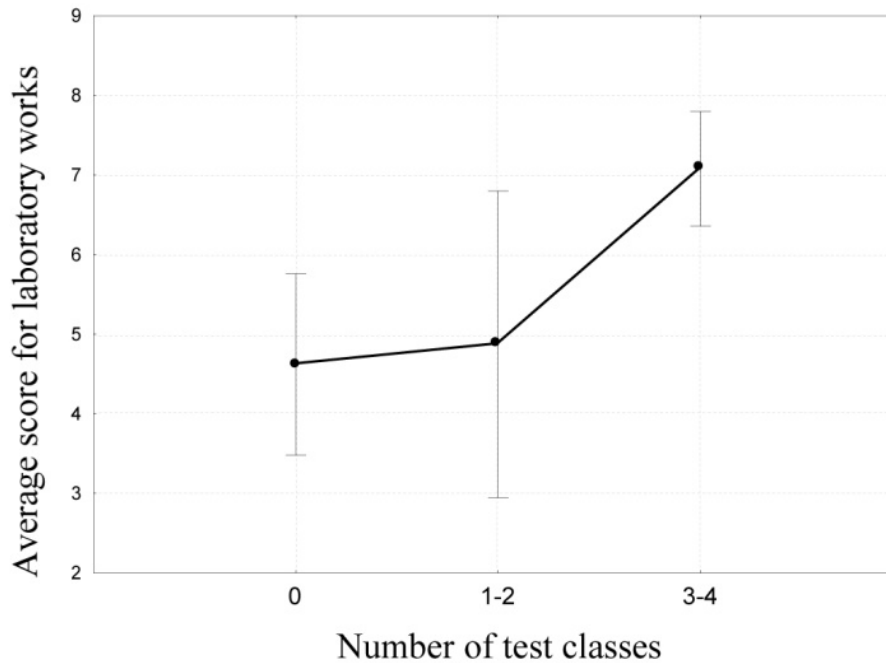


Figure 1. Average values of “average score for laboratory works” and confidence interval (95 %) in groups with different test class attendance rate

For students, who had attended 3 to 4 test classes, the average score for practical works and exam grade were statistically much higher, than for students not having attended test classes or having only attended 1-2 classes (Table 1).

Table 1. Average values (M) of “average score for laboratory works” and difference significance level (Tukey HSD test) in groups with different attendance rates

	group 1 M=4,62	group 2 M=4,87	group 3 M=7,08
group 1		0.8	0.002*
group 2	0.8		0.005*
group 3	0.002*	0.005*	

Figure 2 shows the dependence between average exam grade (subject “Software development technology”) and attendance of test classes.

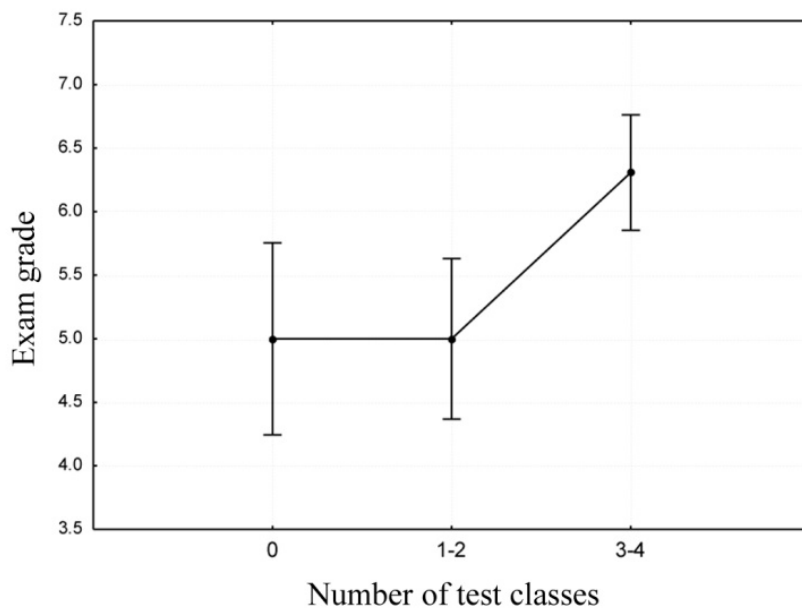


Figure 2. Average values of “exam grade” and confidence interval (95 %) in groups with different test class attendance rate

The next table includes information on the level of significance of differences in the three groups with different test class attendance rate (Table 2).

Table 2 Average values of “exam grades” (M) and levels of significance of differences (Tukey HSD test) in groups with different test class attendance rate²

	group 1 M=5,00	group 2 M=5,00	group 3 M=6,31
group 1		1.0	0.005*
group 2	1.0		0.003*
group 3	0.005	0.003*	

Thus, the acquired data show that those students have higher performance, who have individually, voluntarily, without any additional external motivation benefited from computer-based learning and knowledge control system.

² In the tables 1 and 2 the following data is represented: the first group is made up of students not having attended test class, the second group – of students having attended 1–2 test classes, the third group – of students having attended 3–4 test classes.

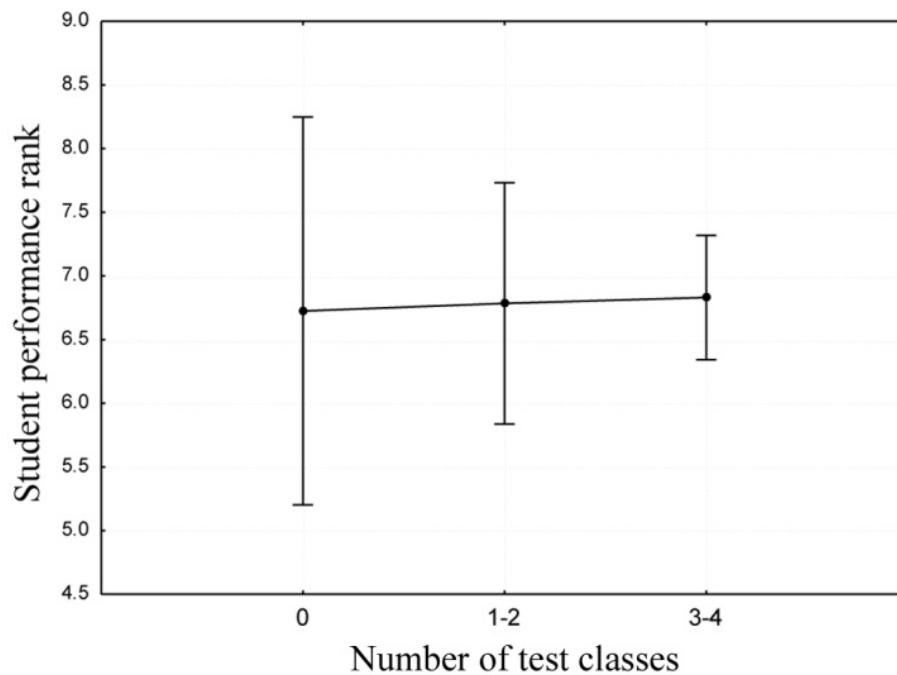


Figure 3. Average values of “performance rank” and confidence interval (95 %) in groups with different test class attendance rate

However the question remains, whether students’ overall attitude toward studies (tests are mostly attended by more successful and motivated students) contributes to these results, or is it fully the consequence of using a computer-based system. In order to find it out, the student’s overall performance at the university was assessed. A hypothesis was made that, if test class attendance will prove to be mutually dependent from overall performance, it will be possible to conclude that higher final grades received by students are mostly due to their individual capacities and not to use of computer-based systems. If, to the contrary, no connection will have been discovered between overall performance and test class attendance, then likelihood is very high that the tests are attended by all students regardless of their attitude toward the study process in general.

Data analysis has revealed that student performance rank does correlate with exam grade value and with average score for laboratory works, but does not correlate with test attendance rate. It was furthermore shown, with the help of ANOVA, that student performance at the university does not statistically significantly differ between groups with different class attendance rate (Fig. 3).

From this it can be concluded that test classes are attended not only by students with high performance and their higher scores for laboratory works and exam grade are consequence of their attending these classes. The second approach also motivated students with various levels of performance to engage in individual studies.

Non-compulsory self-control of knowledge: effects on the performance of students enrolled in the course

The scheme of learning described above computer courses was used by students for independent knowledge acquisition and control. The task was to find out, what role in student learning can be played by computer-based knowledge control, considering the fact that such systems can also be used by students themselves for self-assessment of their knowledge in the respective field. In order to optimize the use of computer systems in the study process, it is important to have a clear understanding of how motivated self-assessment is connected to student performance in a given subject. The question of motivation becomes particularly important when the use of computer-based systems depends on the free choice of students, i. e. under conditions of non-compulsory self-study and self-control.

In the aims of this research, first year students were offered the opportunity to freely complete the tests in “Data structures”. As a motivating factor, the score acquired in the tests was taken into account in producing the final exam grade.

The research was conducted in groups of students of the following specialties: computer systems (134 students), informational technologies (116 students) and automation and computer equipment (64 students). During a semester a prevalent majority of the first grade students (72,3 %, 227 students) attended all test classes, 2 test classes were attended by 12,1 % (38 students), 1 test class – 8,3 % (26 students) and 7,3 % (23 students) didn't attend a single test class. IT must be noted that test class attendance rate statistically significantly ($p < 0,05$) correlated with presence of exam grade (Fig. 4), with Spearman's non-parametric correlation coefficient being 0,41.

As it can be seen from the diagram, the number of students having passed the exam did not statistically significantly vary in groups having attended one test class and not having attended any.

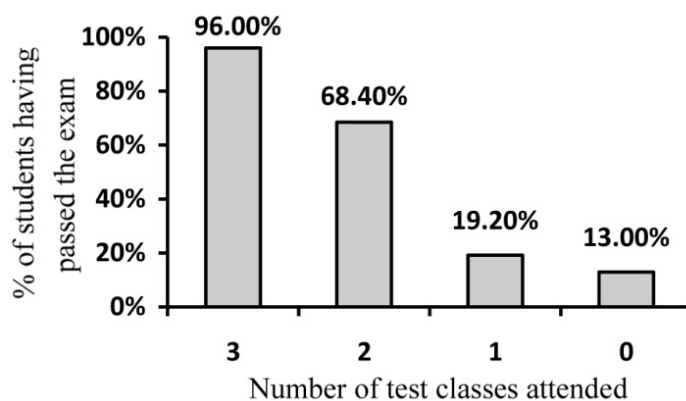


Figure 4. Relative number of students having passed the exam in “Data structures” depending on their test class attendance rate

The analysis of laboratory work scores in “Data structures” depending on test class attendance showed that the average laboratory work score does not depend on the number of test classes attended.

At the same time, in the group of students that had passed the exam, there existed a statistically significant ($p < 0,05$) correlation with Spearman’s correlation coefficient being 0,31 between scores obtained for tests and laboratory classes. Furthermore, test class attendance rate statistically significantly correlated with laboratory work attendance rate (Spearman’s correlation coefficient 0,49, $p < 0,05$).

It must also be noted that all first year students who have passed the exam and were transferred to the next year had attended at least one test class in “Data structures” during the academic year.

The research however showed that general performance of students during the semester has statistically significant correlation ($p < 0,05$) to performance indicators in the “Data structures” subject. The correlation coefficient of general performance of students during with average grade for test tasks is 0,31, with grade for the course paper – 0,43, and with average grade for work at laboratory classes – 0,38.

Thus, the results show that:

- average laboratory class grades did not depend on how often self-control was performed;
- however, these grades were higher for students with higher test grades;
- students who made less use of computer-based self-control were more often absent from classes;
- performance in the “Data structures” course correlated with performance in other subjects.

The acquired results show that students independently used the knowledge control system when they had sufficient motivation. It was established that non-compulsory self-control of knowledge positively affected the quality of studies. Such approach can foster skills of individual learning which are crucial to adapt to the demands of contemporary working environment.

Conclusion

Transformations taking place in the world today set new requirements to study process. Traditional educational paradigm gives way to intensive independent learning activity. Both students’ capacity to self-study and technologies that can foster it acquire greater and greater significance (Rupšienė & Mažionienė, 2011). The traditional educational paradigm presupposes compulsory knowledge control performed by the teacher. However,

such system does not allow to effectively educate a person that would be capable of independently improving their skills. Students' motivation poses a complicated issue, as independent study requires active stance to acquiring new knowledge, i. e. self-motivation.

In the conducted research we assessed the possibility of use of LMS and ORTUS systems by students for independent study and self-control of knowledge in the situation when these systems are not declared compulsory. We also discussed the way the use of such systems affects student performance. The results show that students are ready to use LMS and ORTUS computer-based systems for individual study and self-control of knowledge.

However, it must be noted that the effectiveness of introduction to the course program of tests for knowledge self-control alone will depend on the level of students' overall performance. Acquired results show that even with positive motivation, test-based self-control was more effective for students with better performance in other subjects. At the same time, unmotivated independent use of the LMS complex system for studying and knowledge control positively affected students' level of knowledge regardless of their performance in all the subjects. Furthermore, such approach motivated students to independently absorb the study material. By way of conclusion we recommend the use of the complex LMS system not only for shaping professional competencies, but also for developing skills of self-study.

We can conclude that independent use of computer-based systems with options of self-study and self-control can foster acquisition of skills of self-study, as well as motivation to acquire knowledge, both of which are so crucial for adaptation in today's world. However, further research is necessary to develop optimal educational technologies for students who differ from one another in terms of their attitude to studies, level of motivation and previous training.

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