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The Role of Electronic Learning Resources in Effectiveness of Student's Class Activity on Mathematical Disciplines

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Abstract: The problem under investigation is important because there exist a necessity to find new tools and techniques for effectiveness of educational activity of students. Electronic learning resources help to enhance and vitalize the range of student's independent work as well as improve the quality of their learning activity. We study the effectiveness of combination of distance learning technologies and traditional forms of education, in addition, there are the advantages of application of electronic learning resources in the class activity of students. The effectiveness of combination of e-learning and the traditional forms of learning is grounded on the analysis of the semester students' progress and the results of the examination on the subject "Mathematical Analysis", application χ^2 criterion, calculation of the statistical Yule factor. Electronic learning resources develop students' abilities to autonomy in learning and cognitive activities. The article materials may serve as a basis for higher school teachers in decision making in favor of the use of electronic learning resources in teaching.

Key words: Enhancement of independent work of students, electronic learning resources, mathematical analysis, the effectiveness of learning activities, the criterion χ^2, Yule coefficient of association

INTRODUCTION

Currently, one of the main tasks of higher professional education is to prepare a specialist who strives for continuous self-education and self-development. The solution to this problem lies not only in the devolvement knowledge and skills by the teacher to students but also in the development of their preparedness to continuous learning, skills in independent search for and use of the information obtained. Therefore, student's independent work is a necessary foundation of the learning process.

In the study of mathematical disciplines most of the independent work is given to the solution of problems on each topic to solidify the acquired knowledge and skills. It is clear that systematic student's individual work is able to influence the quality of student's learning activity. Educational experience shows that the independent work of students with textbooks is difficult because of the formality of rendering, lack of control of mastering the knowledge and inability to work with literature. Therefore, it is necessary to find other forms of further education intended to bring student's independent work to a new level of development.

One of such forms of education is electronic education. Electronic Learning Resources (ELR) are the backbone of e-learning. Electronic learning resource is an educational resource designed and realized based on the basis of the computer technology.

Improving the quality and efficiency of learning activity of students is the aim of the introduction of e-learning. It determined the purpose of the study: how e-learning is able to activate the student's independent work and as a consequence, enhance their learning activities.

The problem of the use of electronic learning systems is familiar to both domestic and foreign researchers. In works by Osin (2005, 2010), Dorofeyeva (2013), Osadchaya (2013), Bordovsky *et al*. (2007), Druzhinina *et al*. (2015), the reference is made to the role of electronic learning resources in the educational process. There is a study on the positive experience of application of electronic learning resources in order to develop the student's persistence in learning activities (Zainullina and Vorontsova, 2015). In the scientific works of foreign colleagues one can know about new technical opportunities offered in e-learning, such as remote laboratories and remote experiments (Tho and Yeung, 2014; Costa *et al*., 2010). The need to vitalize distance learning in small rural American schools has been

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investigated by Varre *et al.* (2010). There is a number of studies with a comparative analysis of the effectiveness of two types of learning (traditional and virtual) in higher school (Kramer *et al*., 2015; Moazami *et al*., 2014). Unlike foreign colleagues, in our study, the comparative analysis is performed between the traditional education and a combination of traditional and e-learning. Moreover, for mathematical background of the differences obtained other statistical criteria and values are used in this study.

The study analyzes the semester students' progress and the results of the examination on the subject "Mathematical Analysis". With the Yule coefficient of association the relation of academic performance and learning to each other becomes evident. The results obtained using χ^2 criterion demonstrate significant differences of student's performance after educational experiment by 95%.

MATERIALS AND METHODS

Theory: Currently, one of the most common forms of E-learning is the LMS Moodle learning management system. This is a freeware web application that allows teachers to work out their own E-learning courses on the subjects and manage the learning process with its help. The peculiarity of application of the ELR is that due to the additional opportunities offered it allows to vitalize and expand the range of students' independent work.

According to the aim of the research, to study the effectiveness of educational electronic learning-based activity of students, the Institute of Economics and Finance K (P) FU conducted a teaching experiment. The experimental base totaled 152 students (76 students in the experimental and control groups each) of the first course of the department of general economics who study on a contract basis.

In the traditional form of "lecture and practical session", learning activity was carried out in the control groups. Traditional forms of learning were combined with online education in the experimental groups.

In the first semester of the first year, the students of the department of general economics study discipline "Mathematical Analysis". In this connection, similarly-named E-course "Mathematical analysis" has been created. This electronic course is divided into training modules that provide a complete interactive multimedia product aimed at learning a certain educational topic. Electronic course contains in each module all the necessary training, support, control materials and methodological instructions.

According to the curriculum, discipline "Mathematical analysis" takes 144 h to be learned. Of these, lectures take 36 h, practical classes 36 and 72 h for independent work. Lectures and practical classes are held once a week. After each theme, the students in the control group were given an independent task to read a lecture and solve in the notebook to give certain numbers of tasks from the book. The students of the experimental group, in addition to the above, were to solve control tasks and pass tests on the topic using the learning resource. By means of the educational resource the students had an opportunity to review the materials of the lectures, read the analyzed problems, discuss solutions of the problems on the forum, ask the teacher.

In the control groups, the checking the level of progress in mastering the material by the students was carried out in the form of surveys, doing sums by the board and in the form of tests. In the experimental groups the on-the-day academic ranking the results of the work performed using the ELR were evaluated and considered. The current academic ranking comprised the marks for the most difficult tests, the others had only the presence of them and if the task was not decided fwithin a certain period, the mark zero was put into the ranking. To encourage the students to actively use E-learning courses at home, the control tasks and assignments of class tests were of the same type.

Chats and forums assisted in conducting monitoring of frequency and length of being online by the students, the number of actions, online control of the homework done by them.

During the semester, the students can gain from 0-60 points on a given academic discipline, of which 44 points are reserved to control and independent work in classroom. Throughout the study, 16 quizzes and tests have been carried out. In our study, we shall consider only these results. A ordinal scale with four gradations is used to measure academic progress: low (from 0-11 points), average (from 12-22 points), more than average (from 22-33 points) and high level of progress (from 34-44 points). To justify incidental or consequential differences of progress in the control and experimental group, the statistical criterion χ^2 is used. To establish the link between the academic performance of students and the type of learning the Yule coefficient has been calculated.

RESULTS AND DISCUSSION

During the year, we were conducted a formative experiment, after which a repeat-evaluation is carried out.

Table 1: The level of academic progress of students in control and experimental groups before and after the experiment

The level of student's progress	The control group before the experiment	The experimental group before the experiment	The control group after the experiment	The experimental group after the experiment
Low	10	12	14	20
Average	25	23	31	41
Above average	29	30	26	15
High	12	11	5	0
The sum	M = 76	N = 76	M = 76	N = 76

Table 2: The Ratio of the number of students with positive dynamics and without dynamics in their progress

	Resultant event		
Event	Dynamics is present	Dynamics is absent	Sum
Traditional and electronic learning	32	44	76
Traditional learning	12	64	76
Sum	44	108	152

All data obtained before and after the experiment in the control and experimental groups are shown in Table 1.

The visual comparative analysis of the control and experimental groups before and after the experiment can be carried out using the graphs, bar graphs, diagrams, percentage ratio. According to Table 1, it was revealed that before the experiment the progress of the experimental group was assessed as follows: "low" 14.47% of the students, "average' 39.47%, "above average" 30.26%, "above average" 15.8% of the students. In the control groups, respectively: "low" 15.79%, "average" 38.16%, "above average" 32.89% and "above average' 13.16% of the total number of the students.

When comparing data of the re-educational assessment on the results of the formative experiment, a positive trend in the progress of the students in the experimental group was revealed, as shown in Table 2. In the experimental groups, the number of students with "low" level of progress decreased by 14.47% and amounted to 0%, with the "average" level decreased by 19.73% and amounted to 19.74% with the level "above average" increased by 23.69% and accounted for 53.95%, with "high level" of performance increased by 10.52% and amounted to 26.32% of the total number of people, respectively. In the control groups, the number of students whose progress level was assessed as "low' decreased by 9.21% and amounted to 6.58%, with the "average' academic performance decreased by 3.95% and amounted to 34.21%, with the progress level "above average" increased by 7.9% and amounted to 40.79%, with "high" level of performance increased by 5.26% and amounted to 18.42%, respectively.

In general, the total number of students with "high" and "above average" academic performance was 80.27% in the experimental group and 60.21% in the control group.

Visual analysis does not allow to conclude about the significance of differences in rates of the control and experimental groups. In turn, the statistical methods of data processing make it possible to quantify the educational phenomena and conclude about randomness or regular occurrence of these differences after the educational experiment. Checking the statistical significance is based on the use of χ^2 test with a significance level $\alpha = 0{,}05$.

Empirical (observed) value of χ^2 criterion for each case is calculated by the formula:

$$\chi^2_{емп} = N \times M \times \sum_{i=1}^{K} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{n_i + m_i}$$

Where:

- n_i = The number of students of the experimental group, having the ith mark
- m_i = The number of students in the control group, having ith mark
- NиM = The total number of students of the experimental and control groups in the study

In this example, we choose a significance level $\alpha = 0.05$ that is the possibility of error is 5%. Since the number of levels K = 4 (four levels of the academic achievement are differentiated "low', 'medium", "above average" and "high"), therefore, the number of degrees of freedom is S = K-1 = 3. From the statistical, tables we get critical $\chi^2_{critical} = 7.8$ for $\alpha = 0.05$ and S = 3.

According to the equation we will calculate all possible pairwise comparisons of the data of the experimental and control groups. So the empirical value of the observed criterion before the experiment for the control and experimental groups according to the equation is as follows:

$$\chi^2_{емп} = 76 \times 76 \times \left(\frac{\left(\frac{12}{76} - \frac{10}{76}\right)^2}{12+10} + \frac{\left(\frac{23}{76} - \frac{25}{76}\right)^2}{23+25} + \frac{\left(\frac{30}{76} - \frac{29}{76}\right)^2}{30+29} + \frac{\left(\frac{11}{76} - \frac{12}{76}\right)^2}{11+12} \right) = 0.312$$

Comparing the empirical and the observed values of χ^2 criterion, we get that $\chi^2_{emp}<\chi^2_{critical}$ as 0.312<7.8. Thus, the students' progress before the educational experiment is about the same.

We calculate the empirical value of criteria for the control group and for the experimental group after the experiment.

$$\chi^2_{емп} = 76\times 76\times\left(\frac{\left(\frac{20}{76}-\frac{14}{76}\right)^2}{20+14}+\frac{\left(\frac{41}{76}-\frac{31}{76}\right)^2}{41+31}+\frac{\left(\frac{15}{76}-\frac{26}{76}\right)^2}{15+26}+\frac{\left(\frac{0}{76}-\frac{5}{76}\right)^2}{0+5}\right)=9.424$$

$\chi^2_{emp}> \chi^2_{critical}$, as 9.424>7.8. The reliability of differences of the students' progress after forming experiment is 95%. Thus, an educational effect applied the the researcher on the experimental group of the students improved their progress on the subject as compared to the academic progress of the students from the control groups.

Similarly, we can calculate the empirical value of criterion after the experiment for the control group and before the experiment for the experimental group. At that χ^2_{emp} = 3.832, $\chi^2_{emp}\leq\chi^2_{critical}$ as 3.832<7.8, educational influence was not applied to any of the groups of students and, therefore, the progress of all students was about the same.

The empirical value of the criterion before the experiment for the control group and after the experiment for the experimental groups will χ^2_{emp} = 23.667. $\chi^2_{emp}>\chi^2_{critical,}$ as 23.667>7.8, i.e., the progresses of the students of experimental and control groups are different.

For completeness of the study, let us determine the relationship between the student's progress and the type of learning. After the analysis being conducted on all 16 performed works, we have compiled 2×2 contingency table (Table 2). The first line of n_{11} is the number of students of the experimental group, whose progress improved during the semester, n_{12}-those students who have no positive dynamics in their progress. The second line n_{21} is the number of students in the control group with the positive dynamics in their progress, n_{22} without dynamics. For Table 2 the Yule coefficient of association K_a was calculated by the following Equation.2:

$$?_{?} = \frac{n_{11}\times n_{22}-n_{12}\times n_{21}}{n_{11}\times n_{22}+n_{12}\times n_{21}} \quad (2)$$

The Yule coefficient of association K_a is equal at that:

$$?_{?} = \frac{32\times 64-44\times 12}{32\times 64+44\times 12}=\frac{1520}{2576}\approx 0.6$$

According to the Cheddok scale, we get that the relation of the chosen form of learning and the dynamics of the student's progress on discipline "Mathematical Analysis" is obvious.

At that the observed value

$$\chi^2 : \chi^2_{emp} = N\times K^2_{a} = 152\times 0.36 = 95.76$$

From the statistical tables we find the critical value $\chi^2_{critical}(\alpha, 1) = \chi^2_{critical}(0.05, 1) = 3.8$. As $\chi^2_{emp}> \chi^2_{critical}$, then the coefficient of association K_a is valid and the dependence between the form of learning and the student's progresses exists.

CONCLUSION

In high school, great emphasis is laid on independent work but freshmen have had no skills of self-management of their time. Only with a systematic control of the teacher's organization of independent work of the first-year students is effective. Electronic learning enables to realize it. Targeted tasks with an organized system of control and self-control of knowledge, the possibility of building individual educational trajectories of the students, the student orientation to the achievement of the final positive result allow to enhance the independent work of students and improve the quality and effectiveness of learning activities. Indeed, in the experimental group, a total number of the students with "high" and "above average" academic performance was 80.27% and in the control group 60.21%. Thus, the qualitative indicator of progress in the experimental group was up to 20.06%.

By the results of the winter exam session on the subject 'Mathematical Analysis' 10 students in the control groups were given "excellent" in the exam and 25 students "good" that is 46% of the total. In the experimental groups, respectively, 15 people got "excellent" in the exam and 34 "good", that is 64,5% of the total. Thus, the qualitative indicator of mastering the material of the course "Mathematical Analysis" in the experimental group was up to 18.5%.

The academic progress level before the start of the experiment, in the experimental and control groups is the same but differs with reliability of 0.95% after the end of the experiment. Therefore, it can be concluded that the effect of the changes in the academic progress on the subject for the students of the experimental group is determined by the use of experimental methods of learning.

The calculated coefficient of association K_a has established a significant link between the optimal chosen combination of the traditional forms of learning and the distance learning technologies and student's academic progress on the subject "Mathematical Analysis".

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