Methods of Measuring the Students' Results Obtained in the Teaching-Learning Process

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Abstract
The experimental implementation and the determination of the efficiency of multimedia teaching-learning technologies was done with the purpose of establishing the necessity of transformations that are paramount for the educational system, in order to synchronize it with the general development tendencies of contemporary society.
In this article I shall present the results of an experiment made at the Faculty of Economics Sciences, specialization Finances Banks. In this scientific experiment we applied the technique of parallel groups which supposes the implication of 4 groups of second year students, 2 groups forming the experimental team for whom the multimedia courses for training process were used and 2 control groups for whom teaching was made in the traditional system.
The application of the statistical methods of processing experimental data attested the hypotheses about the positive impact of the implementation of the multimedia courses in teaching- learning process in the experimental groups and the efficiency of the applied methods to the experimental groups, compared to traditional methods, applied to control groups.
The research in question has tried to propose a new perspective for performing the learning-teaching process, corresponding to present requirements, which, by using information technology, offers new possibilities to stimulate interest, new ways for active involvement of the student in the knowledge process.

Keywords: traditional teaching-learning process, multimedia technology, knowledge acquiring coefficient, automation coefficient, efficiency coefficient.

Introduction

Within the measuring activity, numbers, i.e. arbitrary values, are assigned to objects or to their respective properties, with the condition that the established measurement rules ensure the viability of the accepted measurement function. Measuring is an indispensable condition for further operations regarding the processing and interpretation the output of the research.

In order for the measuring to observe the validation conditions it is mandatory to determine the characteristics of the phenomena which we intend to measure and to use the most adequate measuring tool. Within educational research we can distinguish several steps of the evaluation:

1 the first step is recording, which consists of detecting the presence or absence of an objective behavioural trait. Within this stage the subjects and their answers are counted, the grades and averages of the same value are counted etc.
2 the second step of the quantitative evaluation is ordering or classifying. It consists of arranging the research objects in an ascending or descending succession. Arranging the parameters based on certain common traits is called the ranking procedure. Arranging the elements of the series is done based on a determined criterion. The place of each element within the series is called its rank, which is attributed a rank number. If the evaluation of the examination performances refers to a test score, the number of points obtained by each student indicates the rank he has within the series, representing the maximum score. ”The numbers obtained with the aid of the ranks can serve as benchmarks for the evaluation of the level of knowledge gain”(Noveanu E., 1999, p.34).

The measurements were done based on the evaluation of the following aspects: the evaluation subsequent to sustaining an ability test and performing a control task, regarding creative abilities. In order to choose the validation criteria for the experimental results we rely on the following categories: the quantity of assimilated information, the awareness regarding the gained information, the degree in which the subject matter was assimilated. These are part of the student’s abilities field and will be applied for the evaluation.

By the quantity of assimilated information we understand the information that was acquired by the student in the teaching-learning process. In order to characterize it we will use the Nes parameter, which will be represented by the number of study elements from the logical structure of the content of the subject matter (Bontaş I, 1998, p.384).

In order to determine the coefficient of knowledge assimilation, an abilities test, corresponding to assimilation level IV and a project theme regarding creative abilities, corresponding to assimilation level V, were elaborated. Determining this coefficient offers the possibility to perform the cumulative evaluation and to acknowledge the realization of the training finalization principle.

Determining the ability to apply the studied subject matter is just as important as estimating the coefficient of assimilation. “…within the examination of the abilities there is a verification of whether the subject is capable of following a certain training path”(Roberts T. S., 2004, p.322). This coefficient depends on managing the performed actions: understanding the tasks, choosing the necessary method, tools, carrying out actions in a concise manner, etc. When the possible performances reach the automation level, the period of time necessary for executing one and the same action is diminished.

The parameter reflecting the awareness level is determined by applying the assimilated knowledge. The value of this parameter is expressed through the Gc coefficient, which is established by the following definition: “awareness is the intellectual and mental activity, the attention for clarification and understanding” (Dicţionar de psihologie, 1996, p.55). Authors Gremalschi L. And Vasilache Gr. propose an evaluation model for students’ knowledge and abilities in which they divide the students’ abilities regarding subject matters pertaining to informatics in six categories: knowledge (Gc=1), understanding (Gc=2), application (Gc=3), analysis (Gc=5), synthesis (Gc=5) and evaluation (Gc=6). Based on the particular traits of the awareness level we will determine the coefficient of subject matter assimilation. Appling these new educational methods and strategies, as well as the new teaching-learning technologies, lead to the realization of the scientific principle, by modernizing the contents and perfecting the level of training.

Interpreting the results of the scientific experiment

In order to evaluate the results of the research (which pursues the validation of the educational techniques), a test and a control task regarding the students' creativity (Cosmovici A., Iacob L., 1999, p.304)were applied in two parallel groups: experimental groups, in which training was performed with the aid of multimedia technology, and control groups, for which the traditional teaching-learning system was employed.

The parameter expressing the quantity of information is calculated based on the number of study elements (Nes). In order to determine Nes we will use the logical structure of the "Databases" subject matter. The number of study elements is thirty (Nes=30). The value of this parameter is relative and it is established by the author of the multimedia training course. Research has shown that the level of generalization of this course depends on the number of study elements included. If the students will assimilate this volume of information, we may consider that the established objectives have been met.

The Assimilation Coefficient

The parameter reflecting the quality of subject matter assimilation is expressed by the assimilation coefficient (Ci). As mentioned before, we establish an awareness level of Gc=4 for the test, because this determines the students' ability to "know, understand, apply and analyse" (Guţu V., Răilean A., 2000, p.206) the information. For the control task, related to the students' "creative abilities", an awareness level of Gc=5 has been established, value which corresponds to the "creative knowledge" level, expressed by the "synthesis" criterion(Bîrzea, C.,1998, p.15-20, 150).

The assimilation coefficient for each student will be determined by expression:

$$Ci=itc/it$$

where: it - the number of questions in the test; itc - the number of correctly answered questions.

Considering that the elaborated test contains 30 questions, (it=30), the questions have been chosen in accordance with "the body of knowledge included" in the course. The test "contains items of varying difficulty" (Iosifescu Ş., 2000, p.129). The data indicating the score obtained by each of the students of the two groups under comparison subsequent to the testing is illustrated in tables 1 – 2, for the experimental groups, and the results of the control groups are presented in tables 3-4.

Table 1: Experimental Group I

Code of student i	Score for student i for the test/task ***itc_i***		Time necessary for the student to complete the test/task ***te_i***		Assimilation coefficient for each student ***Ci=itc/30 Test/task***		Automation coefficient for each student ***Ca=te/40 Test/task***		Real efficiency coefficient for each student ***Crl=itc/te Test/task***	
IE1	24	9	35	26	0.80	0.9	0.88	0.65	0.69	0.35
IE2	22	8	38	28	0.73	0.8	0.95	0.70	0.58	0.29
IE3	29	8	32	28	0.97	0.8	0.80	0.70	0.91	0.29
IE4	30	10	40	25	1.00	1	1.00	0.63	0.75	0.40
IE5	15	7	27	27	0.50	0.7	0.68	0.68	0.56	0.26
IE6	26	7	26	32	0.87	0.7	0.65	0.80	1.00	0.22
IE7	18	6	30	40	0.60	0.6	0.75	1.00	0.60	0.15
IE8	23	8	31	26	0.77	0.8	0.78	0.65	0.74	0.31
IE9	27	8	40	31	0.90	0.8	1.00	0.78	0.68	0.26
IE10	19	10	30	30	0.63	1	0.75	0.75	0.63	0.33

Table 2: Experimental Group II

Code of student i	Score for student i for the test/task ***itc_i***		Time necessary for the student to complete the test/task ***te_i***		Assimilation coefficient for each student ***Ci=itc/30 Test/task***		Automation coefficient for each student ***Ca=te/40 Test/task***		Real efficiency coefficient for each student ***Crl=itc/te Test/task***	
IIE1	25	9	35	26	0.83	0.9	0.88	0.65	0.71	0.35
IIE2	29	7	38	35	0.97	0.7	0.95	0.88	0.76	0.20
IIE3	28	10	32	26	0.93	1	0.80	0.65	0.88	0.38
IIE4	30	8	40	25	1.00	0.8	1.00	0.63	0.75	0.32
IIE5	17	9	27	27	0.57	0.9	0.68	0.68	0.63	0.33
IIE6	26	6	26	38	0.87	0.6	0.65	0.95	1.00	0.16
IIE7	18	10	30	25	0.60	1	0.75	0.63	0.60	0.40
IIE8	26	8	31	28	0.87	0.8	0.78	0.70	0.84	0.29
IIE9	30	9	40	25	1.00	0.9	1.00	0.63	0.75	0.36
IIE10	21	10	30	25	0.70	1	0.75	0.63	0.70	0.40
IIE11	24	10	28	26	0.80	1	0.70	0.65	0.86	0.38
IIE12	39	9	39	25	1.30	0.9	0.98	0.63	1.00	0.36

Table 3: Control Group I

Code of student i	Score for student i for the test/task ***itc_i***		Time necessary for the student to complete the test/task ***te_i***		Assimilation coefficient for each student ***Ci=itc/30 Test/task***		Automation coefficient for each student ***Ca=te/40 Test/task***		Real efficiency coefficient for each student ***Crl=itc/te Test/task***	
IC1	19	5	38	38	0.63	0.5	0.95	0.95	0.50	0.13
IC2	18	6	38	38	0.60	0.6	0.95	0.95	0.47	0.16
IC3	25	4	32	40	0.83	0.4	0.80	1.00	0.78	0.10
IC4	28	7	40	39	0.93	0.7	1.00	0.98	0.70	0.18
IC5	15	7	39	38	0.50	0.7	0.98	0.95	0.38	0.18
IC6	24	6	36	39	0.80	0.6	0.90	0.98	0.67	0.15
IC7	18	6	30	38	0.60	0.6	0.75	0.95	0.60	0.16
IC8	22	7	31	39	0.73	0.7	0.78	0.98	0.71	0.18
IC9	21	5	40	40	0.70	0.5	1.00	1.00	0.53	0.13
IC10	14	5	37	40	0.47	0.5	0.93	1.00	0.38	0.13

Table 4: Control Group II

Code of student i	Score for student i for the test/task *itc_i*		Time necessary for the student to complete the test/task *te_i*		Assimilation coefficient for each student *Ci=itc/30 Test/task*		Automation coefficient for each student *Ca=te/40 Test/task*		Real efficiency coefficient for each student *Crl=itc/te*	
IIC1	20	6	38	39	0.67	0.6	0.95	0.98	0.53	0.15
IIC2	17	4	38	40	0.57	0.4	0.95	1.00	0.45	0.10
IIC3	26	5	32	40	0.87	0.5	0.80	1.00	0.81	0.13
IIC4	21	7	40	38	0.70	0.7	1.00	0.95	0.53	0.18
IIC5	16	5	39	39	0.53	0.5	0.98	0.98	0.41	0.13
IIC6	23	4	36	40	0.77	0.4	0.90	1.00	0.64	0.10
IIC7	18	5	30	40	0.60	0.5	0.75	1.00	0.60	0.13
IIC8	20	6	31	39	0.67	0.6	0.78	0.98	0.65	0.15
IIC9	22	7	40	37	0.73	0.7	1.00	0.93	0.55	0.19
IIC10	13	7	37	38	0.43	0.7	0.93	0.95	0.35	0.18
IIC11	12	8	40	38	0.40	0.8	1.00	0.95	0.30	0.21
IIC12	25	10	35	40	0.83	1	0.88	1.00	0.71	0.25

Based on the value of the assimilation coefficient, we take into consideration the following cases:

1 If the assimilation coefficient Ci ≥ 0.7, the subject matter is considered to be assimilated at a high level;
2 If 0.5 ≤ Ci < 0.7, the subject matter is considered partially assimilated;
3 If Ci < 0.5, the subject matter is not assimilated (therefore it is necessary to revise the content of the questions).

We have selected the data regarding the frequency of the assimilation coefficient (fi) from tables 1.- 2. and 3.-4. (table: 5).

Table 5: The Frequencies of the Assimilation Coefficient

Experimental Groups		Control Groups	
The frequency of the assimilation coefficient (fi)	The assimilation coefficient (Ci)	The frequency of the assimilation coefficient (fi)	The assimilation coefficient (Ci)
0	0.4	1	0.4
0	0.43	1	0.43
0	0.47	1	0.47
1	0.5	1	0.5
0	0.53	1	0.53
1	0.57	1	0.57
2	0.6	3	0.6
1	0.63	1	0.63
0	0.67	2	0.67
1	0.7	2	0.7
1	0.73	2	0.73
1	0.77	1	0.77
2	0.8	1	0.8
1	0.83	2	0.83
3	0.87	1	0.87
1	0.93	1	0.93
2	0.97	0	0.97
4	1	0	1

The frequency of the assimilation coefficient is the number which indicates how many times the enumerated value of the assimilation coefficient is found.

The data from the synthetic table (5) are illustrated graphically through the areolar diagrams (see fig. 1 and fig. 2), the surfaces of which are divided based on the frequency of the assimilation coefficient.

Fig. 1. The assimilation coefficient for the experimental groups

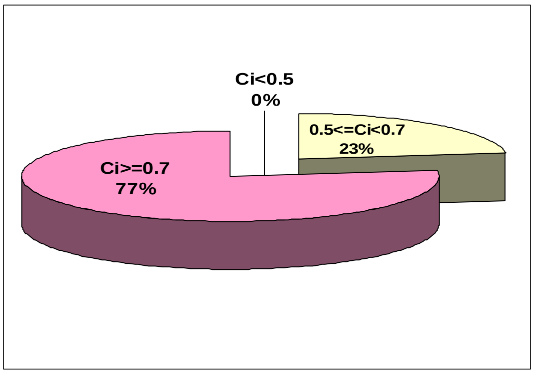
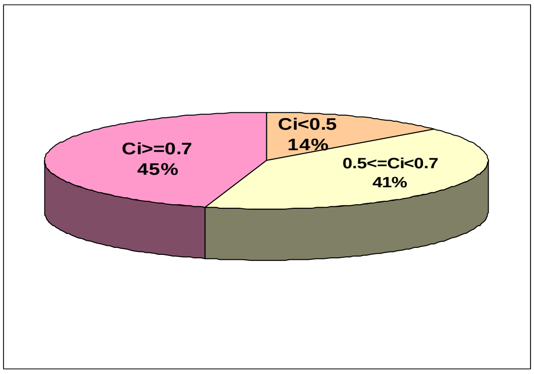


Fig.2. The assimilation coefficient for the control groups



The diagram (fig.1) shows that the outcome of the experiment is the following: 5 students of the 22 in the experimental groups have a smaller assimilation coefficient, which constitutes 23%. The majority, however: 17 students, representing 77% have an assimilation coefficient larger than 0.7 and we can therefore consider the subject matter assimilated in these cases. The situation in the control groups is reflected in diagram (fig.2). Subsequent to the analysis of this diagram we conclude that the situation in the control groups is the following: 3 students with results inferior to 0.5, which constitute 14%; 9 students amounting to 41% have an assimilation coefficient between 0.5 and 0.7, which denotes a superficial assimilation of the subject matter and only ten students (45%) have assimilated the subject matter completely.

This analysis demonstrates that experimental groups, in which modern teaching-learning technology has been employed, the assimilation coefficient is larger compared to the one found in control groups, where traditional training methods were employed.

Used expression:

$$Ni = it*n; \quad Nic = \sum_{i=1}^{n} itc_i$$

where: it – the number of questions in the test; n – the number of students in a group; itci – the number of questions answered correctly by student i; Ni – the total number of questions proposed for the entire group; Nic –the total number of correct answers generated by the experimental or control groups.

We will determine the assimilation coefficient for each group (Ci) according to the following expression:

$$Ci = Nic/Ni$$

For the experimental group we have: For the control group we have:

Group1	Group2	Group1	Group2
Ni=300	Ni=360	Ni=300	Ni=360
Nic=233	Nic=304	Nic=204	Nic=233
Ci=0,776	Ci=0,844	Ci=0,68	Ci=0,647

The average assimilation coefficient for each of the two groups will be calculated according to the simple average formula and will indicate the following results: 0.81 for the experimental group and, accordingly, 0.66 for the control groups.

By analyzing the results obtained we conclude that the required level of knowledge assimilation has been attained and the necessary volume of information has been acquired in all the groups. By applying the data from the tables above, we illustrate the comparative graphs for the average assimilation coefficient, calculated for each of the groups (fig.3). As we can see, within the experimental groups, the subject matter assimilation coefficient is higher than the one found in the control groups.

In order to analyze the results of performing a control task, an awareness level of Gc=5 was established for the experimental and control groups. The value of the task was awarded with a quota of 10 (It=10).

Fig. 3 The average training coefficients within the experimental and control groups in case of applying the test

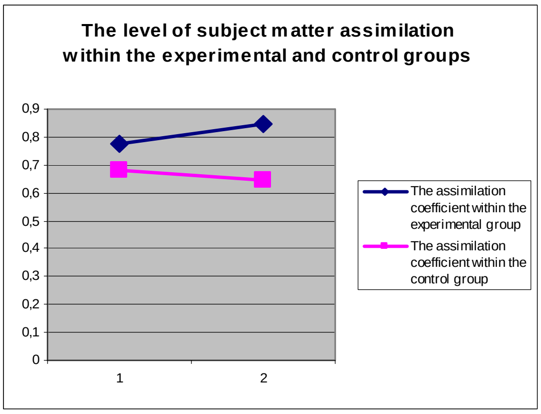
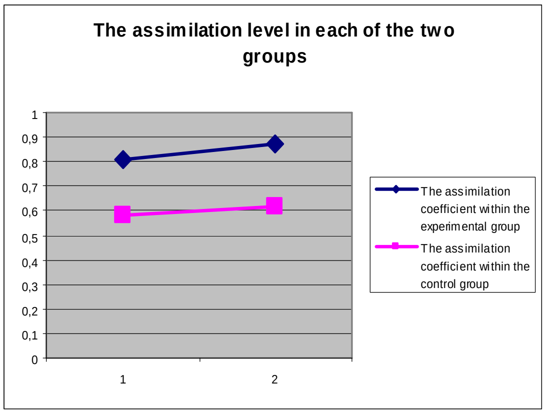


Fig. 4. The average training coefficients in experimental and control groups in case of applying the creativity task



The data, which indicates the score obtained by each of the students of the two groups, are highlighted in synthetic tables: table 1 - table 2 and, accordingly, table 3 – table 4. In the abovementioned tables, the values of the assimilation coefficient are reflected, for each group of students recorded after performing the creativity task.

For the experimental group, we have: For the control group, we have:

Group1	Group2	Group1	Group2
Ni=100	*Ni=120*	*Ni=100*	*Ni=120*
Nic=81	*Nic=105*	*Nic=58*	*Nic=74*
Ci=0,81	*Ci=0,875*	*Ci=0,58*	*Ci=0,616*

The average assimilation coefficient for each group will indicate the following results: 0.8425 for the experimental group, and 0.598 for the control group.

Subsequent to the analysis of the results received, we can state that the subject matter has been assimilated, and that the proposed objectives have been accomplished.

The automation coefficient

The students' performance level, regarding the abilities to apply the knowledge and to manipulate the implicit tools, will be determined according the time required to complete the test. The automatization coefficient, symbolized Ca, will be determined from expression:

$$Ca = te/tp$$

where: tp - estimated time for completing the work tasks; te – the time it takes the student to complete the assigned tasks.

The data, expressing the value of the automatization coefficient, calculated for each of the students of the two groups under comparisson, are represented for the experimental groups in table 1 and table 2 and for the control groups, in tables 3 and 4.

Expression:

$$Tp = tp * n, \quad Te = \sum_{i=1}^{n} te_i$$

where: tp - estimated time for completing the work tasks; te_i – the time it takes the student to complete the assigned tasks; Tp – total estimated time; Te – the total time necessary for the students to complete the assigned tasks.

The average automatization coefficient, which illustrates the relation between the total estimated time Tp and the total time necessary for task completion Te, for each of the groups will be calculated according to the expression:

$$\overline{Ca} = \frac{\sum_{i=1}^{n} te_i}{n * tp} \quad \text{sau} \quad \overline{Ca} = \frac{Te}{Tp}$$

The data indicating the value of the average automatization coefficient, calculated for each of the groups are presented in the following table.

Tabelul 6: The average automatization coefficients for each experimental and control group

Experimental Group			**Control Group**		
Group	*The average assimilation coefficient*	*The average automatization coefficient*	*Group*	*The avergae assimilation coefficient*	*The average automatization coefficient*
For the test					
E I	0,776	0,8225	CI	0,68	0,9025
E II	0,844	0,825	CII	0,647	0,9083
$\overline{Ca}$	**0,82375**		$\overline{Ca}$	**0,9054**	
For the control task					

E I	0,81	0,7325	I	0,58	0,9725
E II	0,875	0,6895	II	0,616	0,975
$\overline{Ca}$	**0,711**		$\overline{Ca}$	**0,97375**	

The smaller the ratio between the period of time necessary for a student to complete a task and the estimated time, the more efficient the automatization coefficient. Subsequent to the analyses resulting from table 6 we can observe that the students belonging to the groups with the highest assimilation level (with a value close to 1), also have a better automatization coefficient. In the control groups, for both the creativity tasks and the tests, almost all of the available time was used, thus proving a relatively weak assimilation coefficient.

We can conclude that, by applying the new teaching-learning techniques, we can manage to help students acquire better computer skills than in the case of traditional training methods.

The efficiency coefficient

We will determine a new parameter illustrating the quality of the training process with the implementation of multimedia courses, expressed by the efficiency coefficient (Ce) of the teaching-learning process. The relative efficiency coefficient referring to the assimilation of the subject matter will be determined by the ratio between the total number of subjects and the estimated time interval.

The real efficiency cofficient will be the coefficient of study matter assimilation by each of the students (i) and will be determined by the ratio between the total number of correct answers and the time interval necessary for student (i) to answer all of the questions of the test:

$$Crl = \frac{itc_i}{te_i}$$

where: Ni – number of questions in the test; Tp – the time available for task completion; itci – the nu8mber of correct answers given by student i; tei – the time necessary for student i to accomplish the assigned tasks.

Tables 1 - 2, 3 – 4 outline the relative efficiency coefficient for each student. For the validation of the results we will compare the values of the efficiency coefficients and we will consider the following cases:

If the real efficiency coefficient (Crl) is larger or equal to the relative efficiency coefficient (Crv) (i.e. Crl ≥ 0.75 then:

a) for 0.75 ≤ Crl < 0.80 – the results are excellent and, subsequently, the teaching techniques are profficient;
b) for 0.7 ≤ Crl <0.75 results are very good, and, so, the applied teaching methods have a high efficiency coefficient;
c) if 0.6 ≤ Crl < 0.7 – results are relatively good, the efficiency coefficient is close to the targeted one;
d) if 0.5 ≤ Crl < 0.6- the efficiency coefficient is small, the teaching-learning techniques require certain modifications;

e) if Crl < 0.5 then the teaching-learning process is inefficient and it is necessary to revise the contents of the course or to change the teaching techniques.

Table 7: Ranking the frequencies of the efficiency coefficients in steps

Experimental Group		Control Group	
Interval	Frequency	Interval	Frequency
0 - 0.1	0	0 - 0.1	0
0.1 - 0.2	0	0.1 - 0.2	0
0.2 - 0.3	0	0.2 - 0.3	0
0.3 - 0.4	0	0.3 - 0.4	4
0.4 - 0.5	0	0.4 - 0.5	3
0.5 - 0.6	2	0.5 - 0.6	5
0.6 - 0.7	6	0.6 - 0.7	5
0.7 - 0.8	8	0.7 - 0.8	4
0.8 - 0.9	3	0.8 - 0.9	1
0.9 -1	3	0.9 -1	0

According to the data in the table, we have elaborated the areolar diagram of the frequencies of the efficiency coefficients (fig. 5-6).

Fig.5. The real efficiency coefficient in the experimental groups

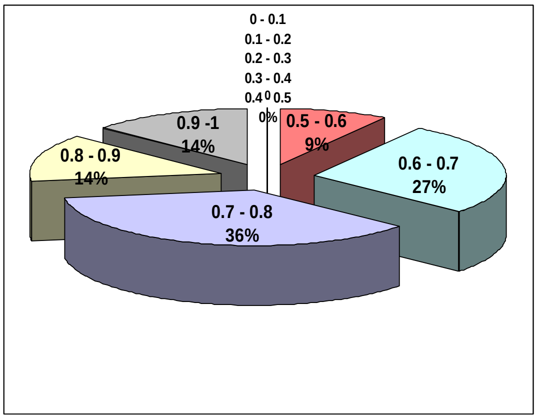
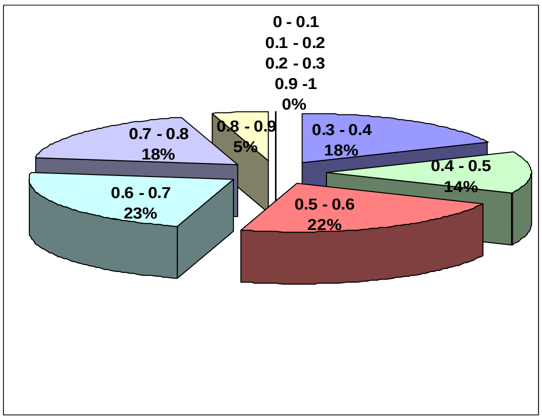


Fig.6. The real efficiency coefficient in the control groups



Thus: in the experimental groups, 3 students, amounting to 14%, have the relative efficiency coefficient between 0.8 and 0.9; 8 students, representing 36%, have the relative efficiency coefficient between 0.7 and 0.8; 6 students – 27% have the relative efficiency coefficient between 0.6 and 0.7; 2 students – 9% have the relative efficiency coefficient between 0.5 and 0.6

Within the control groups(fig. 6.), the situation is as follows: 1 student, representing 5%, has the relative efficiency coefficient larger than 0.8; 4 students, i.e. almost 18% have a relative efficiency coefficient placed between 0.7 and 0.8; 5 students – 23% have a relative efficiency coefficient between 0.6 and 0.7; 5 students, 22%, have a relative efficiency coefficient between 0.5 and 0.6; 3 students, amounting to 14% have a relative efficiency coefficient between 0.4 and 0.5; and 4 students, representing 18% have a relative efficiency coefficient smaller than 0.4.

The average efficiency coefficient within the experimental groups is calculated by using the simple average method for the coefficients in each group and has the value of 0.75; and for the control groups, 0.55.

We notice that, in the case of the educational experiment within the experimental groups, the teaching efficiency coefficient is larger or equal to 0.75 (case a), and we can therefore consider the teaching process an efficient one. Within the control groups, however, the teching efficiency coefficient is smaller, placed between 0.5 and 0.6 (case d), which expresses the inefficiency of the traditional teaching-learning method. In this case, the multimedia courses contain too much information for it to be assimilated by traditional methods, within the predetermined timeframe.

Conclusions

The students which have obtained a larger knowledge assimilation coefficient, stayed within a smaller timeframe than the one available for task completion, at a superior efficiency coefficient. Therefore we can conclude that by applying information technology in the teaching-learning process we receive the following result:

1. an increase in the volume of assimilated information (assimilation coefficient, memory capacity);
2. a diminishing of the time interval necessary for the assimilation of knowledge and acquiring computer skills (the automation coefficient);
3. an increase of attention, parameter which is more difficult to quantify, but which has a large influence throughout the learning-teaching activity. With the help of multimedia effects, we can focus the attention on key elements of the information displayed.

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