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ASSESSMENT OF THE IMPLEMENTATION OF NEW METHODOLOGICAL TOOLS IN EXPERIMENTAL STUDIES IN COMPUTER NETWORKS AND COMMUNICATIONS

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Abstract. This paper presents the evaluation of the implementation of new methodological tools for the experimental training course in “Computer Networks and Communications” for university students of Informatics. Using the statistical processing of the results of the conducted training, the given hypothesis was proved, that visualization of the theoretical content of the lectures through software provisional visual and dynamic models (simulacra) improves the quality of education and assists the formation of students’ knowledge and skills.

Key words: computer networks and communications, training, methodological tools, simulacrum, knowledge, skills, competencies, statistical analysis.
2000 Mathematics Subject Classification: 97D20, 97D40, 97C30, 97C90.

1. Introduction

We are seeing a massive influx of Computer Networks and Communications (CNC) into practice. The telecommunications sector is an area of high growth in the European economy and is its important stimulator. This growth rate is caused by the increasing need for fast and quality services. This is achieved mainly by a change in technologies, particularly in terms of digitization and data transfer. These facts determine the necessity to increase the knowledge of the average computer user in the field of CNC. Therefore, secondary school students study CNC in the compulsory subjects of Informatics and Information Technologies. Specialized training in these disciplines expands their knowledge and skills in the field of CNC and prepares students for professional training in the field of computer sciences that are studied in universities. CNC is a basic course in all universities where there are bachelor degree programs available for professionals in the field of computer sciences.

The course syllabus for "Computer Networks and Communications" for students of Informatics from the Faculty of Mathematics at Plovdiv University, provides theoretical knowledge in the field of computer networks connected to the existing models and standards, their types and protocol stacks. On a practical level, the emphasis is put on the physical parameters for building networks of the type IEEE 802.3 and IEEE 802.11, network commands for diagnostic and management of certain types of routing devices, etc.. The expected results are related to the acquisition of knowledge and skills to build and manage local home and office networks etc.

Since 2009 in the Faculty of Mathematics and Informatics of Plovdiv University "Paisii Hilendarski", they have begun to work on new methodological tools for teaching the discipline of CNC seeking to illustrate the theoretical content. Gencho Stoitsov has been developing software for creating provisional visual and dynamic models, called simulacra. So far 22 models of this type have been created and are actually used in the training of students. Publications [1], [2], [7], [1] and [7] are dedicated to experimental learning with the new methodological tools.

2. Purpose and organization of the study

A pedagogical research was done during the academic years 2010/2011 and 2011/2012 with students from the Faculty of Mathematics and Informatics of Plovdiv University "Paisii Hilendarski", doing the CNC course. The aim of this study was to prove the working hypothesis that the illustration of the theoretical content of CNC by provisional visual and dynamic models enhances the quality of learning and assists the process of formation of students' knowledge and skills.

For inspection and possible proof of the given hypothesis, the results of the currently applied approach, which uses minimal materials for illustration and no simulacra included, are compared to the proposed methodology, including rich content of provisional visual and dynamic models (simulacra included). The purpose of this article is to offer a more detailed description and evaluation of the conducted experimental training, using the methods described in [1], [2], [7].

The selection of experimental and control group for the study was random, by using the administrative division into courses. As the developed provisional visual and dynamic models are designed to enrich and illustrate the course lectures, it is virtually impossible to divide into groups, which is the main reason for the courses to be used as such.

The general population of the study are students from the academic years 2010/2011 and 2011/2012, doing the CNC course. The random sample is formed on the basis of students from one course of different majors in the Faculty of Mathematics and Informatics of Plovdiv University "P. Hilendarski". The following samples have been set up:

- **Sample 1** – *Major*: Informatics, *Form of study*: part-time, *Degree*: Bachelor, *Number of students*: 48; *Test 'A'*: 17; *Test "B"*: 31, *Questions*: 17;
- **Sample 2** – *Major*: Software Engineering, *Form of study*: full- time; *Degree*: Master; *Number of students*: 20; *Test 'A'*: 12; *Test "B"*: 8; *Questions*: 17;
- **Sample 3** – *Major*: Informatics, *Form of study*: full-time; *Degree*: Bachelor, *Number of students*: 123; *Test 'A'*: 64; *Test "B"*: 59, *Questions*: 17;
- **Sample 4** – *Major*: BIT; *Form of study*: part-time, *Degree*: Bachelor, *Number of students*: 32; *Test 'A'*: 16; *Test "B"*: 16, *Questions*: 17;
- **Sample 5** – *Major*: BIT, *Form of study*: full-time; *Degree*: Bachelor, *Number of students*: 61; *Test 'A'*: 32, *Test "B"*: 29, *Questions*: 17;
- **Sample 6** – *Major*: Informatics, *Form of study*: full-time; *Degree*: Bachelor, *Number of students*: 48; *Test 'A'*: 20; *Test "B"*: 28, *Questions*: 17;

The study involved a total of 332 students, divided into two groups: **Group 1 – 161 students** and **Group 2 – 171 students**. The total number in each group was obtained after summing up the number of students from different samples corresponding to the particular group. A verifying experiment has been conducted, and its results show insignificant difference between the average results of the six samples, allowing us to conclude that the start of the course is accompanied by equal opportunities for the participating students [4].

Two versions of the test are prepared for the final experiment: Test A (for group 1) and Test B (for Group 2), which have different data in the terms of the tasks. The aim is to reduce the possibility of improper interference by other students during the exam.

The measured learning objectives are that the learner to be able to:

1. Name, define and list in sequential order the levels of the OSI model;
2. For any given protocol data unit to determine the level of the OSI model, to which it belongs;
3. Define, list and explain any given basic concept of the thematic content;

4. Identify, list, define and explain the given standards and their specifications;
5. Define and implement the T568A and T568B standards, which provide an opportunity for the realization of the Straight (straight-through) and Cross (crossover) cable;
6. Name and list in the correct order the levels of TCP / IP protocol stack, protocols and addresses corresponding to these levels;
7. List the classes of IP addresses in IPv4 standard and calculate their borders;
8. Configure subnets, gateways and IP addresses for distribution;
9. On a given subnet mask to determine its accuracy;
10. For any given level of the OSI model to name the valid intermediary device and understand its use.

Criteria and indicators for evaluation of the results

Four main criteria are used to evaluate the results of the final experiment [6]:

1. Criterion 1 – Knowledge related to the OSI model [5];
   - 1.1. To name, define and list in sequential order the levels of the OSI model;
   - 1.2. To name protocol data units and determine the level of the OSI model, to which they belong;
   - 1.3. To know how the OSI model functions;
2. Criterion 2 – Knowledge and skills related to LAN and WAN
   - 2.1. To define basic concepts associated with this type of networks;
   - 2.2. To identify, list, define and explain the given standards and their specifications;
   - 2.3. To define and implement the T568A and T568B standards;
3. Criterion 3 – Knowledge and skills related to the consistency of heterogeneous networks
   - 3.1. To name and list the intermediate network devices and indicate the level of performance in relation to the OSI model;
   - 3.2. To explain its use and the way it functions;
4. Criterion 4 – Knowledge and skills related to the operation of the TCP / IP protocol stack [8]
   - 4.1. To name and list in the correct order levels of TCP / IP protocol stack, the protocols and addresses corresponding to these levels;
   - 4.2. To list the classes of IP addresses in IPv4 standard and calculate their borders;
   - 4.3. To configure subnets, gateways and IP addresses for distribution;

4.4. On a given subnet mask to determine its accuracy.

3. Analysis of the final test results

The final test was conducted for the corresponding samples after three months of training. To prove the main hypothesis, two groups are formed – the **control** and the **experimental group**. The distribution of the samples into groups is as follows:

- Samples using lectures with minimal lecture materials to illustrate and not simulacra included – Sample 1, Sample 2;
- Samples using lectures with enriched content of provisional visual and dynamic models (simulacra included) – Sample 3, Sample 4, Sample 5, and Sample 6.

The presentation is shown in Table 1.

Type of group	Included samples	Number of students		Total number	
		Group 1 (Test A)	Group 2 (Test B)	Group 1 (TestA)	Group 2 (Test B)
Control group	Sample 1	17	31	29	39
	Sample 2	12	8		
Experimental group	Sample 3	64	59	132	132
	Sample 4	16	16		
	Sample 5	32	29		
	Sample 6	20	28		
		Total		161	171

Table 1. Distribution of the samples in groups

Both tests provide two parallel studies to confirm or reject the suggested hypothesis.

Processing the results for group 1 (Test A)

The control group consists of 29 students, and the experimental of 132. The frequency distribution of the examination marks of the two groups is presented in Table 2.

Test	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Number	Average marks	Successful
CONTROL GROUP																				
A	0	1	3	1	2	4	7	1	1	2	0	3	2	1	1	0	0	29	7.79	34%
EXPERIMENTAL GROUP																				
A	1	4	1	2	4	4	6	9	15	16	13	17	7	13	10	5	5	132	10.67	77%

Table 2. Frequency Distribution of Test A results

The table shows that the difference in the average score is 2.87, and the percentage of successful students is 43% (the criterion that a test is successfully passed is min 9 points) in favor of the experimental group. These results confirm the given hypothesis. It remains to check whether this difference is a result of the improved methodological tools or is accidental.

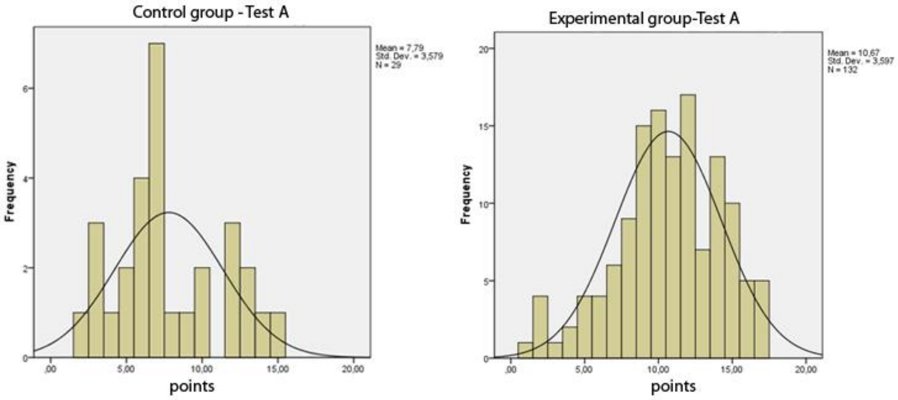

Figure 1. Histograms of the control and experimental group-Test A

For that purpose, a check for normal distribution of the empirical data of the two formed groups is necessary, which will allow us to select the method of comparison. When processing the results with the SPSS program, we established the following:

- The Shapiro-Wilk test (Table 3) applied to the control group, Test A and intended for small samples, returns a value of ***Sig.*** (degree of significance) over 0.05 (0.106) **which is sufficient to draw a conclusion about the normal distribution of the test results**.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control group Test A	,208	29	,002	,941	29	,106

Table 3. Tests of Normality

- The tests of Kolmogorov-Smirnov and Shapiro-Wilk (Table 4) applied to the experimental group, Test A, return values of ***Sig.*** respectively **0.016** and

0.005, **which is sufficient to draw a conclusion about the abnormal distribution of the test results**.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experimental group Test A	,087	132	,016	,970	132	,005

Table 4. Tests of Normality

From the drawn conclusions of the two groups, it becomes necessary to use a non-parametric test to compare the results of the two independent populations. For this purpose, a comparative analysis was made with the U-criterion of Mann-Whitney, which returns a result of 000 for **Asymp. Sig. (2-tailed)**. Based on this result (degree of significance < 0.05) it can be concluded that **the difference between the two measurements is not accidental, but is the result of our actions. In other words, the confirmation of our hypothesis is of no random character**.

Processing the results for group 2 (Test B)

The control group consists of 39 students, and the experimental of 132.

The frequency distribution of the results of the examination marks of the two groups is presented in Table 5.

Test	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Number	Average marks	Successful
CONTROL GROUP																				
B	1	3	3	3	1	0	6	2	3	2	3	4	3	0	1	4	0	39	8.64	51%
EXPERIMENTAL GROUP																				
B	1	2	1	1	4	4	8	9	8	18	15	13	12	15	12	5	4	132	10.99	77%

Table 5. Frequency distribution of Test B results

The table shows that the difference in the average score is 2.35, and the difference in the percentage of the successful students is 26% (the criterion for the test to be successfully passed is min 9 points) in favour of the experimental group.

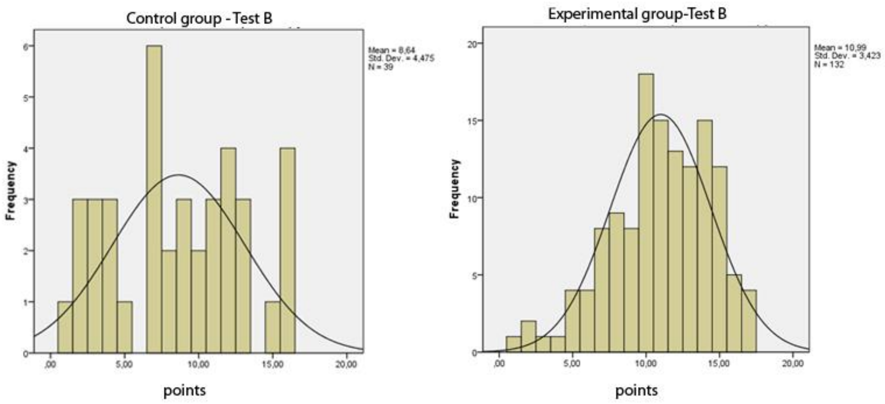

Figure 2. Histograms of the control and experimental group-Test B

The results for checking the normal distribution of the empirical data of the two formed groups shows the following:

- The tests of Kolmogorov-Smirnov and Shapiro-Wilk (Table 6), applied to the control group-Test B, return values of **Sig. 0.200** and **0.086** respectively, **which is sufficient to draw a conclusion about the normal distribution of the test results**.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control group Test B	,107	39	,200*	,951	39	,086

Table 6. Tests of Normality

- The tests of Kolmogorov-Smirnov and Shapiro-Wilk (Table 7), applied to the experimental group-Test B, returns a value of **Sig. - 0.003** and **0.004** respectively (degree of significance <0.05), **which is sufficient to draw a conclusion about the abnormal distribution of the test results**.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experimental group Test B	,098	132	,003	,969	132	,004

Table 7. Tests of Normality

The conclusions show that it is necessary to use a non-parametric test to compare the results of two independent populations. For the purpose, the analysis is made again with U-criterion of Mann Whitney, the result of which for **Asymp.Sig. (2-tailed)** is **003**. Based on this result (degree of significance <0.05) a conclusion can be drawn again that **the difference between the two measurements is not accidental, but is the result of our actions. In other words, the confirmation of our hypothesis is of no random character**.

Conclusions and Evaluation

1. A pedagogical research is done on 332 students, divided into two parallel groups (Group 1 and Group 2);
2. Two versions of the test are used: Test A for Group 1 and Test B for Group 2;
3. A posteriori analysis of the final tests is done;
4. The obtained results are evaluated by IBM SPSS software, for the analysis of the research results, using the U-criterion of Mann-Whitney for two independent samples to reject the assumption of accidental nature of the result;
5. Based on the activities mentioned above, as well as on the obtained results, we can conclude the following: **The results of the parallel tests A and B confirm the hypothesis that visualizing the theoretical content of CNC by provisional visual and dynamic models improves the quality of training and assists the process of the formation of knowledge and skills.**

Additional conclusions and evaluation

A number of additional conclusions can be made on the basis of the obtained results. For example, the division of the experimental group into subjects, allows us to trace the impact of the used methodology and tools in the courses.

Sample	Major	Group	Type of distribution		Average marks
Sample 1	Informatics (part-time)	Group 1	normal	normal	8.22
		Group 2	normal		
Sample 2	Software development technologies (full-time)	Group 1	normal	normal	7.82
		Group 2	normal		
Sample 3	Informatics (full-time)	Group 1	abnormal	abnormal	11.36

		Group 2	abnormal		
Sample 4	BIT (part-time)	Group 1	normal	normal	8.94
		Group 2	normal		
Sample 5	BIT (full-time)	Group 1	normal	normal	10.97
		Group 2	normal		
Sample 6	Informatics (full-time)	Group 1	normal	normal	10.56
		Group 2	normal		

Table 8. Experimental group and majors

Based on calculations made, the evaluation of the distribution of the separate groups, and of the major in general, is shown in Table 8. On their basis we can conclude:

1. The used methodology and tools ensure a constant level of mastering the study material in different subjects;
2. The low score of the BIT course, part-time (Sample 4, group 2) is due to the involvement of students in the economic sphere and their inability to attend lectures.The result obtained, from a statistical point of view, is comparable to that of the samples of the control group where the materials for visualizing the theoretical content are minimal and there are no dynamic models.

4. Conclusion

The main hypothesis of the conducted dissertation research, that visualizing the theoretical content of CNC by provisional visual and dynamic models enhances the quality of education and assists the formation of the knowledge and skills, was confirmed by the results of the conducted pedagogical experiment.

The received objective information proves the availability of the learning content, proposed in the research and the effectiveness of the developed teaching methodology.

The developed models and tools for teaching computer networks and communications can enrich the current pedagogical practice in teaching the subject at university.

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ОЦЕНКА НА ПРИЛАГАНЕТО НА НОВ МЕТОДИЧЕСКИ ИНСТРУМЕНТАРИУМ ПРИ ЕКСПЕРИМЕНТАЛНО ОБУЧЕНИЕ ПО КОМПЮТЪРНИ МРЕЖИ И КОМУНИКАЦИИ

Генчо Стоицов, Коста Гъров, Стефка Анева

Резюме. В настоящата статия се описва оценка на прилаганенето на нов методически инструментариум при експериментално обучение по учебната дисциплина „Компютърни мрежи и комуникации" на студенти от университетската специалност Информатика. С помощта на статистическа обработка на резултатите от проведеното обучение се доказва направената хипотеза, че онагледяването на теоретичната част от учебното съдържание чрез софтуерни условно изобразителни и динамични модели (симулакруми) повишава качеството на обучение и подпомага процеса на формиране на знания и умения у обучаемите.