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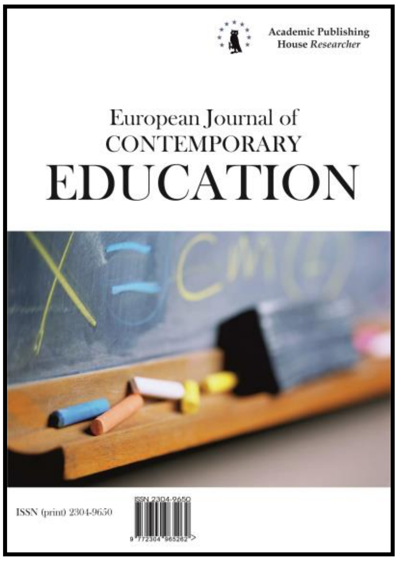

Organization and Carrying out the Educational Experiment and Statistical Analysis of its Results in IHL

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Abstract

The article discusses the methodological approach to the technology of the educational experiment performance, the ways of the research data processing by means of research methods and methods of mathematical statistics. The article shows the integrated use of some effective approaches to the training of the students majoring in «Technological education». The purpose of article is to check the efficiency of the created didactic support that helps to ground the students majoring in «Technological education» in the technologies of modern production at the university. It shows the features of introduction of the created didactic set of the hi-tech educational laboratory equipment based on digital technologies with program control into the educational process. The materials of the article can be useful to university lecturers, school teachers (teachers of Physics, Mathematics, Technology etc.) and students of teachers training and technical institutions, colleges, schools.

Keywords: educational experiments, methods of mathematical statistics, students majoring in «Technological education», didactic set as learning aid.

1. Introduction

Educational experiment is a complex, time-consuming method of scientific psychoeducational research, it is carried out for the purpose to check the suggested hypothesis and assumes the solution of a certain set of tasks.

Psychoeducational experiment is a complex research method which provides the scientifically based and evidential check of the correctness of the hypothesis suggested at the beginning of the research. The essence of the experiment consists in the active researcher's intervention in the psychoeducational process with the purpose to study it in the planned parameters and conditions (Obraztzov, 2004).

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It is based on the comparison of the control and experimental groups and registration of the corresponding changes in the behavior of the studied object or system.

A set of statistical data on characteristics and properties of the studied objects which serves as a criterion of the validity of the scientific hypotheses, theoretical conclusions and operational recommendations is a result of any educational experiment.

Up to the end of the XIX century scientists considered the use of logical conclusions to be sufficient for the establishment of the validity of the solutions of many pedagogical problems. Modern pedagogics demands the scientific validity of all the hypotheses. This means that the educational experiment performance, the control of independent variables (which are considered to be the possible reasons of the changes of dependent variables) and dependent variables (which are considered to be the possible consequences of the factors of independent variables) and also the application of modern methods of mathematical statistics to prove the importance of the elicited facts are necessary.

2. Literature Review

Many authors devoted their works to educational experiments: Avanesov, 1989; Babansky, Zhuravlev, Rozov, 1988; Bespalko, Tatur, 1989; Bobrovskaya, 2015; Grabar, Krasnyanskaya, 1977; Zhuravlev, Novikov, Skatkin, Piskunov, 1979; Zagvyazinsky, 1993; Morozov, Pidkasisty, 1991; Naumkin, Grosheva, 2010; Naumkin, 2013; Novikov, 1998; Obraztsov, 2004; Osintseva, 2005; Slastenin, Podymov, 1997; Tynnikov, 2015; Tyunnikov, 2016. They describe the tasks facing the researchers conducting educational experiments, the factors influencing the research procedures and give some recommendations that can help to plan and process the received results, etc. Despite a large number of the works devoted to the questions mentioned above, many beginning researchers experience some difficulties in their studies. The questions of the correct planning of their experiments, the possibilities of their realization, the right definition of the values of the studied variables, the choice of techniques for objective and reliable processing of the experimental results, the possibilities of their exact interpretation, etc. worry them. This can be explained by the fact that:

1) the majority of the mentioned above scientists' works regarded as classic in pedagogics and psychology have sections devoted to experimental pedagogics and as a rule they are written in high academic style (there are few examples from practice);

2) in the works the scientists consider some separately taken sections of experimental pedagogics (for example, logic of educational researches, methods of pilot study, methods of mathematical statistics, etc.).

All this allows to draw a conclusion about the difficulties the students face to connect theory with practice while conducting educational pilot studies. Therefore the objective of the given research is to work out the techniques of organization and carrying out educational experiments, and mathematical processing of the results for the students of the Faculties of Technology and Business, Technology and Economics, Mathematics, Informatics and Natural Sciences, Major stream «Pedagogical Education» in IHL.

3. Materials and methods

The purpose of the educational pilot study is to check the efficiency of the created teachware for teaching students majoring in «Technological education» to the bases of the technologies of modern production (to electrophysical and electrochemical methods of processing of materials in particular).

The educational experiment was preceded by the students' formation of knowledge, skills while studying the electrophysical and electrochemical methods of processing of materials. Also the whole complex of didactic teachware was created: the course program «Bases of Electrophysical and Electrochemical Methods of Processing of Materials», the lecture course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials» (Sidorov, 2016), the set of educational and laboratory installations on electrospark (Sidorov et al., 2010), high-frequency electrospark processing (Sidorov et al., 2011), processing of materials and metal hardening by currents of high frequency (Sidorov et al., 2010) was designed and made; the methodical recommendations for conducting laboratory workshops on processing of materials by methods of electrospark, high-frequency electrospark processing and metal hardening by currents of high frequency; the educational tests for determination of the level of mastering the basic concepts of the course.

The main documents while at assessing the level of the students' knowledge and abilities before and after the introduction of the new components of the educational process into the educational experiment were: payrolls of the groups (control and experimental ones), educational tests, contents of the students' answers while studying the course and protocols of their analysis. The actual material received in such a way was applied to compare the level of their assimilation of the basic concepts of the studied material.

Second-year students of the Faculty of Mathematics, Informatics and Natural Sciences, Major strem «Pedagogical Education», profile «Technological Education» in Ershov Ishim Teachers Training Institute (branch) of Tyumen State University, Omsk Teachers Training University and the Faculty of Technology and Business of Kemerovo State University took part in the educational experiment. In the course of carrying out the experiment 287 people participated in it (144 students – the experimental group and 143 people – the control group).

The research problems were connected with the experimental check of the effective use of the didactic teachware (the high-tech educational laboratory equipment based on digital technologies with program control for the improvement of the quality of the technological training of the students majoring in «Technological Education».

The chosen groups of students were completely identical (the same year of the beginning of their study, the year of study, the age etc.). The level of knowledge and the number of students in groups were the same. In the experimental groups while teaching students to the bases of electrophysical and electrochemical methods of processing of materials we applied the technique based on the use of the created didactic set of the high-tech educational laboratory equipment based on digital technologies with program control, and in the control groups the traditional technique of teaching students was used.

Under the traditional technique used in the control groups we meant the carefully selected, specifically recorded and analysed options of traditional teaching that could be opposed to the experimental options. «Traditional training is a training when a teacher is focused first of all on instructing students and explaining them the ways of actions intended for the reproducing assimilation; a teacher is the only active and initiative person in the educational process. Traditional training has mainly a reproductive character» (Osintseva, 2000).

While carrying out any educational experiment for receiving some objective and reliable data its planning plays an essential role. The plan defines the character of separate stages of any experiment and the order of their realization. Researchers use different plans of experiments: with the use of stating and check experiments together with forming, stating and forming ones, forming and control ones and others.

We will give an example of the comparative experiment used in psychoeducational researches more often and as a rule it includes three stages:

At the first stage of the stating experiment we chose two groups (experimental and control ones). We determined the initial condition of the level of the formation of the students' technological training while studying the modern methods of processing of materials. For this purpose we organized special testing in both groups and the preexperimental knowledge and abilities acquisition which showed that the students had a low level of technological preparation in the field of high-tech production with the use of technological innovations (electrophysical and electrochemical methods of processing of materials in particular).

At this stage for the organization and carrying out the educational experiment we tried to create all the necessary conditions: we equipped the laboratory on processing of constructional materials with modern teachware; created the high-tech educational laboratory equipment on processing of constructional materials by methods of electrospark, high-frequency electrospark processing and material hardening by currents of high frequency; determined the content of the future Technology teachers' theoretical and practical training, teaching them to electrophysical and electrochemical methods of processing of materials; developed and introduced in the educational process the course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials» based on the use of the high-tech educational laboratory equipment; integrated the content of technological and general technical disciplines with physics, chemistry; created the diagnostic tools for determination of the efficiency of the students' educational cognitive activityts.

The work was carried out for collecting the material for creation of the program and the content of the course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials», the methodical instructions on conducting laboratory workshops. We designed a set of the hi-tech educational and laboratory installations on processing of constructional materials by methods of electrospark, high-frequency electrospark processing and metal hardening by currents of high frequency.

At this stage of the experiment we organized observation, discussions, questioning and testing, thus we managed to estimate the students' readiness for using scientific knowledge, laws of physics, chemistry in productions, their readiness for integration of the content of natural-scientific, general technical and technological disciplines while explaining the work of various equipment, etc. (Grocheva, 2015).

The analysis of the questionnaires showed that 85 % (243 students) had no sufficient knowledge for the realization of integration of the content of various disciplines. But 100 % (287 students) showed some interest in gaining the necessary knowledge. More than 92 % (264 students) (in Ishim – 100 %) were neither familiar with the devices and the principle of the work of the equipment (electrospark, high-frequency electrospark processing and metal hardening by currents of high frequency) nor saw them. But at the same time the students understood that the knowledge was necessary for their individual development and professional growth. The low level was shown while solving the creative tasks that demanded the knowledge of various disciplines – 25 % (71 students).

The second stage of the experiment – a forming one – is connected with the introduction of the didactic set connected with the course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials» into the educational process. In this regard in the experimental group during the students' acquaintance with high-tech production we used the created set of educational and laboratory installations of the high-tech equipment based on digital technologies with program management (Sidorov et al., 2010, 2011). The classes were given with the application of the problem and research methods. Each step assumed the realization of the students' creative activity on the bases of the the didactic principle – the connection of theory and practice. In the control group we used the traditional technique of teaching students without the use of the high-tech educational laboratory equipment.

The main objective of this stage of the experiment was the identification of the influence of the use of the set of the high-tech educational laboratory equipment in the experimental group while teaching the students majoring in «Technological education» to the bases of electrophysical and electrochemical methods of processing of materials. During this stage of the pilot study the following problems were solved:

- experimental confirmation of the positive influence of the use of the set of the hi-tech educational laboratory equipment on the quality of formation of the students' practical skills;
- justification of the didactic expediency of the use of the educational laboratory equipment in the course of teaching students mahoring in «Technological education» to the bases of electrophysical and electrochemical methods of processing of materials;
- introduction to students the methods of educational and research work at classes with the use of the hi-tech educational laboratory equipment and the project-based learning.

The students made the educational and research experiment to find the optimum modes of processing of materials according to the type of the work environment, some electrical parameters, the time of the tool influence on the details that allowed students to understand the entity of electrophysicochemical methods of processing of materials.

In the methodological recommendations to the laboratory course about carrying out the educational and scientific work consisting in the study of the principles of the installation functioning, its construction, the modes of processing of different materials there were tasks connected with the explanation of some production processes from the point of view of Physics and Chemistry, the assessment of the structural changes and the mechanical properties in case of metal hardening by currents of high frequency (Science of materials). Besides, the students were offered the tasks connected with the improvement of the laboratory equipment and design of other equipment with the use of some laws of Physics and Chemistry. At the end of the course of study we suggested some diagnostic tests to reveal the level of the students' knowledge and abilities to realize their integration while studying different subjects, their abilities to solve creative problems, etc.

It turned out that in the check groups where instead of the laboratory course we used special literature during the practical lessons the students' knowledge, skills and abilities to solve creative tasks were lower – 17–55 % (according to different parameters).

So, the students of the experimental groups showed the abilities to integrate knowledge from different subjects 30 % higher, their designer and construction knowledge – 47 % higher. All the students of the experimental groups were ready to solve creative tasks, in the check groups the number of such students is about 65 % (186 people). The same we could see in case of the assessment of the students' level of mastering skills in independent work with different equipment and instruments, with educational literature. In the experimental groups all the students were engaged in scientific researches – they showed better abilities to analyze the results of their independent researches and to draw conclusions. Comparing the results of the students' proficiency to operate different laboratory installations in different IHL we could see that at Tyumen State University where the equipment is better than at Omsk State Teachers Training University and Kemerovo State University the results according to the cognitive and creative parameters were 12 % higher.

The third stage of the experiment – the control experiment had the following objective – the final check of the results of the forming stage of the experiment and the final confirmation of the research hypothesis that specified the technique of holding lectures and the laboratory course aimed at the students' acquaintance with the bases of electrophysicochemical methods of processing of materials with the use of the created set of the high-tech educational laboratory equipment and the methodological recommendations to the laboratory course. At the end of this third stage of the experiment the control test (cutoff) was carried out. The cutoff reflected the completeness of the students' assimilation of the main concepts of the studied material. The cutoff allowed to draw the conclusion that the applied technique of teaching the students majoring in «Technological education» to the bases of electrophysical and electrochemical methods of processing of materials using the created set of the high-tech educational laboratory equipment (ectrospark, high-frequency electrospark processing and metal hardening by currents of high frequency) in the experimental group was more effective in comparison with the traditional techniques applied in the check groups without the use of the mentioned above educational and laboratory installations.

To reveal the students' level of assimilation of the concepts of the course «Basis of electrophysical and electrochemical methods of processing of materials» we worked out special tests.

4. Discussion

A large number of works are devoted to the questions connected with theory and techniques of organization and carrying out educational monitoring, they give some recommendations about the scientific organization of the system of educational monitoring with the use of modern test technologies. They are: the organization of the experimental work at school for principals, teachers, tutors (Zagvyazinsky, 1993); the scientific psychological research with the elements of mathematical statistics (Nemov, 1999); the experimental work in educational institutions (Novikov, 1998); the system and methodical support of teaching and educational process in training specialists (Bespalko, Tatur, 1989); the scientific organization of educational monitoring in IHL (Avanesov, 1989); the scientific educational researches (Babansky et al., 1988); the mathematical statistics in educational researches (Grabar, Krasnyanskaya, 1977); the materials and methods of educational researches (Zhuravlev et al., 1979); the structure of competence in innovative development (Naumkin, 2013, 2014); the methods and methodology of psychological and educational researches (Obraztsov, 2004); the pedagogical bases of education standardization and training graduates at the teachers training universities in general technical disciplines (Osintseva, 2000); the teachers' training for innovative activities (Morozov, Pidkasisty, 1991); the system of the future teachers' training for innovative activities (Tynnikov, 2015); the correlation of assessment and self-assessment in diagnostic procedures for the assessment of the teachers' innovation (Tyunnikov, 2016); the techniques of carrying out educational experiments and the results of researches (Sidorov, 2014).

«Education test is a system of tasks characterized by the increasing difficulty and its specific form which allows to estimate the structure and to measure the level of knowledge, skills» (Avanesov, 1989).

The use of test tasks allows to check the quality of the students' assimilation of the studied material in a short period of time and to define the directions for individual work with every student. The main «instrument» of test check is the test that includes two basic elements: a task and a standard-a model of the correct and high-quality task performance to which the course and the results of the students' work are compared.

While working out the tests we applied the technique offered by V.P. Bespalko. According to him, there are tests of four levels (Bespalko, Tatur, 1989):

Level 1 – tests for identification, distinction and classification of the studied objects. They require to recognize the studied information during its reexperience (action with a hint);

Level 2 – tests for identification of the students' abilities to reproduce the information without any hint and without books: a substitution test where a word, a phrase or other text element are intentionally passed; a constructive test that assumes the students' independent reproduction of information without a hint or a book; a test-standard task in which the gained knowledge is applied in standard situations;

Level 3 – tests – non-standard tasks demanding heuristic, non-standard actions. These tasks can be of two versions: tasks demanding transformations of the acquired technological data or the ways of actions and tasks for training of spatial imagination, spatial and creative thinking.

Level 4 – tests for identification of the students' creative abilities, research opportunities according to the information, new to this branch of science.

The considered above Levels 1 and 2 connected with the assimilation of the studied material became the basis for the created test tasks. Test check gives a chance to check the formation of the students' knowledge, abilities, skills (at the level of their acquaintance with the studied material and its reproduction) without any significant classroom time consumption.

Tests are usually set in the form of list of questions demanding short and definite answers or in the form of tasks which solution doesn't take a lot of time, but requires unambiguous solutions. Using such a method it is very important to decide on the criteria for the evaluation of the students' successful test performance. The coefficients of the students' assimilation of knowledge and abilities can be a quantitative expression of these criteria (Bespalko, Tatur, 1989).

It is necessary to bear in mind that the quality of control of the students' proficiency depends on the quality of the used test.

While creating the qualitatively made measurements (tests) it is necessary to follow the following criteria of their quality determination: validity, simplicity, definiteness, unambiguity, objectivity, efficiency and reliability (Zagvyazinsky, 1993).

The criterion of test validity is a concept which represents an indicator of the test compliance to the studied material of the course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials» by students majoring in «Technological education» for their training for the future work at school. Validity tests were carried out by means of the delphi technique connected with the attraction to the assessment of the studied material of the most competent people whose opinions supplementing and rechecking each other allowed to estimate objectively the studied process. The experts were highly skilled teachers of the IHL where the experiment was conducted. They were offered to answer every question in the test (only «yes - no»). In other words they were offered to answer the following question: «Do you think that every question of this test corresponds to the purpose of the given research?» At the same time the level of the objectivity of the studied information depended on the number of independent experts. The higher the number, the higher the reliability of the information. As a rule, the number of the experts involved shouldn't be less than six people, in our case number of experts were 10.

The results of the questioning are presented in Table 1.

The validity criterion β of the created test tasks were calculated by the formula (1) (Osintseva, 2000).

$$\beta = \frac{(a_1 + a_2 + a_3 + a_n)}{100 \cdot n} = \frac{12680}{100 \cdot 130} = 0.97 \quad (1)$$

where a_n - a sum of all the experts' positive estimates about the need of the inclusion of each of the offered tests, expressed in percent;

n - a number of test tasks.

This formula is applicable only in the cases when each value of a > 50%. The tests are considered to be valid if the value $\beta \geq 0{,}63$. In our case the calculated value β was – 0,97 that demonstrated rather high validity of the created test tasks.

The criteria of simplicity, definiteness and unambiguity were defined from the application of the tests for creation of which Bespalko and Tatur's technique of test creation was applied (Bespalko, Tatur, 1989).

The inclusion of the tasks of the two equivalent levels of complexity (1 and 2) in the tests formed the basis of the determination of the criterion of simplicity of the test tasks. Each test task was presented by a task, a question or a statement. The students had to perceive all the test tasks, keep them in memory and try to answer the question. So we tried not to trouble them during this period of activity with additional difficulties.

The criterion of definiteness of the tests was found in the course of the experiment by organizing the observations of the students for the purpose of the identification of correctness of their understanding of the test tasks. The students reading the tests were to understand well what knowledge and skills and in what volume they had to demonstrate.

Table 1. Criteria of objectivity of the test tasks

Test number	Expert number										Sum of positive opinions, %
	1	2	3	4	5	6	7	8	9	10	
1	+	+	+	+	-	+	+	+	-	-	70
2	+	+	+	-	+	+	+	-	+	+	80
3	+	+	+	+	+	+	+	+	+	+	100
...											
129	+	+	+	+	+	+	+	+	+	-	90
130	+	+	+	+	+	+	+	+	+	+	100

The necessary existence in the test tasks of standard answers containing their correct and full contents was provided with the criterion of unambiguity of the test tasks.

The criterion of objectivity of the test tasks was reached with the help of equal conditions for the students in the course of their implementation: each student got a package of equivalent tasks containing 13 tests and covering the whole studied course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials». Before testing all the students were instructed about the procedure of testing (to avoid all the possible misunderstanding when processing the test results). The students were given the time necessary to complete the test. They were not given time to think over the answer. The total time to complete all the test tasks was about 30 minutes, about two minutes per a test.

The criterion of efficiency of the test tasks was established by the careful analysis of the students' answers. For this purpose we revealed easy and difficult tasks:

- the test all the students gave 95-100 % correct answers was easy;
- the test 0-5 % students could fulfill was difficult.

Such tests as a rule have no differentiating ability to distinguish the students who know the subject better from those who know worse. In our pilot study among all the test tasks we revealed only one (Test 5), 95–100 % students fulfilled it (Avanesov, 1989).

5. Results

To ensure the criterion of reliability and validity of the assessment of the test tasks we sampled the values of the coefficient of the students' acquisition of knowledge and abilities connected with the studied material using Bespalko and Tatur's technique (Bespalko, Tatur, 1989).

The tests consisted of two parts – tasks and standard answers. The tasks were given to the students, the standard answers were the models of correct and consistent fulfillment of the tasks. With the use of standard answers it was easily to determine the figure p of the essential operations necessary for the complete fulfillment of the test. Comparing the students' answers with standard answers for determining the correct operations the tests gave the chance to define the coefficient of completeness of the students' acquisition of the basic concepts of the course K. It was calculated on the following formula (2),

$$K = a/p \qquad (2)$$

where a - a quantity of the students' correct answers; p - a quantity of the standard answers.

This coefficient was normalized to the condition $0 \leq K \leq 1$. If the average value of the coefficient of the students' acquisition of the basic concepts of the course $K \geq 0,7$ we considered the material to be studied well. In our case the value Kexp. = 0,83 (Tyumen State University); Kexp. = 0,82 (Kemerovo State University); Kexp. = 0,81 (Omsk State Teachers Training University) fit into the framework of the interval (0,7-1) that we tried to reflect in the following histogram (Fig. 1).

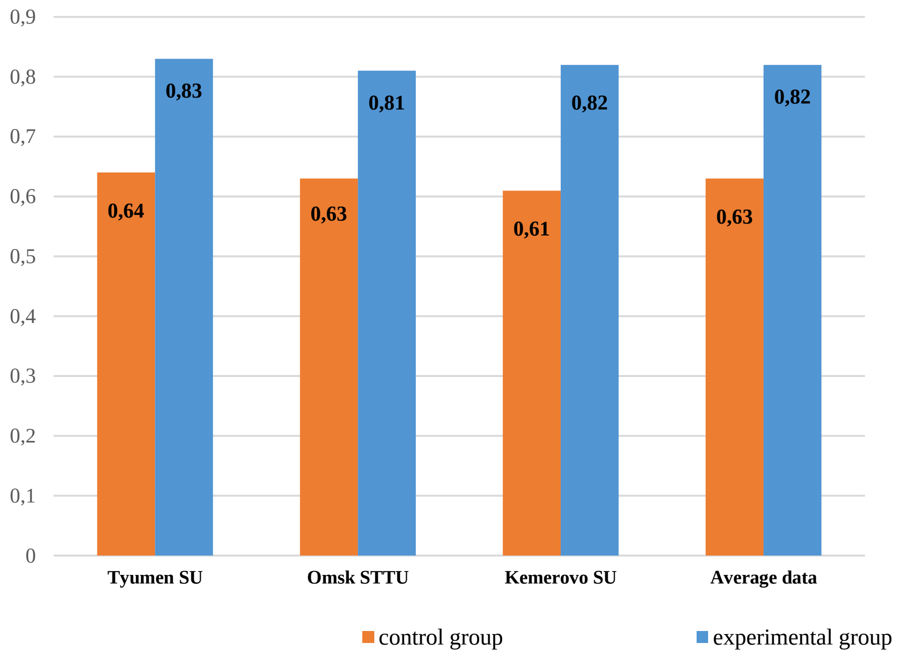

Fig. 1. Experimental and control groups

On the basis of the obtained data in the control and experimental groups we defined the coefficient of the effectiveness of the applied technique η, equal to the relation of average coefficients of the students' acquisition of the basic concepts of the course in the groups using the formula (3):

$$\eta = K_{exp.} / Kcont. \qquad (3)$$

where Kexp. - the coefficient received in the experimental group;

Kcont. - the coefficient received in the control group.

In the experimental group the applied technique was more effective in comparison with the traditional technique in the control group when $\eta > 1$.

The results of the pilot study at Tyumen State Uuniversity, Kemerovo State University and Omsk State Teachers Training University allowed to define the coefficient of the students' acquisition of the basic concepts of the course and the efficiency of the applied technique.

From the histogram we see that the applied training technique in the experimental group with the use of the created didactic set of the high-tech educational laboratory equipment based on digital technologies with program control was more effective in comparison with the traditional one we had applied in the control group (without the use of the above-mentioned educational laboratory equipment). It promoted the high quality of the students' acquisition of the basic concepts of the course «Bases of Electrophysical and Electrochemical Methods of Processing of Materials».

For the exact analysis of the efficiency of the applied experimental technique it was necessary to check the experimental data by methods of mathematical statistics and we did it. For this purpose we used the Student's t-test oriented on the check of the reliability of the data as we show below.

For the assessment of the criterion of tests reliability the splitting technique was used. We created the final test tasks (10 variants for Levels 1 and 2). Each variant consisted of 13 test tasks.

All the test tasks were divided according to the principle of division into even and odd questions. In that case we assumed that two parts of one variant would correlate as they would be fulfilled by one student.

Below we will review an example of the determination of the criterion of tests reliability for Variant I option of the final test. 10 students fulfilled it (Table 2). The criteria of the test reliability for other variants were defined in the same way

where $P_{эij}$ - the quantity of the correct standard answers of i (student) and j (the variant number of the even and odd parts of the test task);

x_{nj} - the quantity of the correct answers of i (student) and j (the variant number of the even part of the test task);

y_{nj} - the quantity of the correct answers of i (student) and j (the variant number of the odd part of the test task);

$\sum Xij$, $\sum Yij$ - the total quantity of the correct answers of i (student) and j (the variant number of the even and odd parts of the test task).

To find the coefficient of reliability of the tests we defined the coefficient of linear correlation (interrelation coefficient) which could change in the range from (– 1) to 1.

Under the correlation we understand the interrelation between two reasons expressed in a quantitative form. It shows how one factor can change relative to the other and how they are related to each other.

In our case we calculated the coefficients of linear correlation, received by ten students in the even and odd parts of the test task for Variant 1. It was (4, 5, 6):

$$SSx_{ij}=[(x_{1j})^2+(x_{2j})^2+ \quad +(x_{nj})^2]-\frac{(\sum x_{ij})^2}{k} = 646.9 \tag{4}$$

$$SSy_{ij}=[(y_{1j})^2+(y_{2j})^2+\dots+(y_{nj})^2]-\frac{(\sum Y_{ij})^2}{k} = 419.9 \tag{5}$$

$$Sp_{xy}=[(x_{1j}\cdot y_{1j})+(x_{2j}\cdot y_{2j})+\dots+(x_{nj}\cdot y_{nj})]-\frac{\sum X_{ij}\cdot\sum Y_{ij}}{k} = 332 \tag{6}$$

where k - the quantity of tasks in the test. So the coefficient of correlation of the two halves of r_k of the test was (7) (Avanesov, 1989):

$$r_k=\frac{Sp_{xy}}{\sqrt{SSx_{ij}\cdot SSy_{ij}}} = 0.637 \tag{7}$$

The received r_k value = 0.637 (Table 4).

The reliability of the assessment of the importance of the relation between even and odd parts of the test was checked with the use of Nemov's technique (Nemov, 1999).

Table 2. Final test tasks for 10 variants

№ task	№ Variant									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1	1	2	3	4	5	6	7	8	9	10
2	11	15	16	12	18	19	13	21	22	23
3	14	24	29	17	25	32	20	26	35	36
4	27	28	37	30	31	38	33	34	48	49
5	40	41	42	43	44	45	39	47	52	62
6	53	54	50	56	51	58	46	60	61	75
7	63	67	55	64	57	71	59	65	74	88
8	66	76	68	69	70	77	72	73	87	101
9	79	80	81	82	83	84	78	86	91	104
10	92	93	89	95	96	90	85	99	100	114
11	105	106	94	108	109	97	98	102	103	117
12	118	115	107	121	116	110	111	112	113	127
13	128	119	120	129	122	124	123	125	126	130

We compared the calculated correlation coefficient with the degree of freedom n - 2, where n - the quantity of the data in the correlated ranks (in our case it was 10). We noticed that the importance of the correlation coefficient depended also on the set level of the accepted probability of errors in the calculations. The connection of even and odd parts of the test is significant if the calculated value of the correlation coefficient exceeds the tabulated value. Between the data of the even and odd parts of the test there was a significant connection as the critical value of the correlation coefficient for 10 - 2 = 8 degrees of freedom and the value of significance equal to 0,05 was 0,6319 that was less the calculated value according to the formula (7).

The reliability of the assessment of the importance of the connection of the correlating values of the even and odd parts of the test we checked using the formula (8).

Table 3. Determination of the criterion of reliability of the tests for Variant 1 of the final task

$P_{эij}$	i	1	2	3	4	5	6	7	8	9	10	$\sum Yij$ $\sum Yij$
22	xnj	19	20	17	15	18	11	7	14	8	13	142
13	ynj	10	11	8	7	12	10	7	5	9	13	92

$$t = \frac{r_k\sqrt{n-2}}{\sqrt{1-r_k^2}} = 2.33 \qquad (8)$$

where n - 2 – the quantity of the degrees of freedom for the correlation coefficient.

We substituted in the formula (8) the value of our correlation coefficient for 10 - 2 = 8 degrees of freedom and got the value of the coefficient t = 2,33, we compared this value with the tabulated value 2,31 with the level of significance 0,05. So we could draw the conclusion that the compared values from the two samples of even and odd parts of the test really statistically and definitely differed with the probability of error less than 0,05 as the received value was more than the tabulated value, so the connection between these two samples of the test was significant, that was reliable (Osintseva, 2005).

For the reliability measurement of the test task we used the reliability coefficient rnt defined with the Brown-Spearman formula (9).

$$r_{nt}=\frac{(\sum x_{ij})^2}{k}=0.78 \quad (9)$$

The values of the reliability and validity coefficients of the test tasks for 10 variants according to the mentioned formulas are specified in table 4.

$$t=\frac{t_1+t_2+...+t_{10}}{10}=2.6 \quad (10)$$

$$r_{nt}=\frac{r_{HT1}+r_{HT2}+...+r_{HT10}}{10}=0.8 \quad (11)$$

Summarizing the received values of the coefficients t and rnt for each variant and dividing into the total quantity of the variants using the formulas (10; 11) we could find the average criteria of the coefficients of reliability and validity of all the tests: the validity criterion of the tests according to the formula (10) is t = 2,6 with the degree of freedom 8 that was more than the tabulated value - t = 2,31. It meant that the compared values from the two samples of even and odd parts of the test were really various with the probability of error less than 0,05, therefore the connection between these two samples of all the tests was really reliable (Nemov, 1999).

Table 4. Values of the coefficients of the correlation of reliability and validity of 10 variants of the final test task

Students	Variant I		Variant II		Variant III		Variant IV		Variant V	
xi, yi	*x*1	y1	*x*2	y2	*x*3	y3	*x*4	y4	*x*5	y5
Рэij	22	13	21	13	10	19	21	26	15	12
1	19	10	11	10	10	10	17	12	7	6
2	20	11	17	7	9	8	15	25	8	7
3	17	8	15	12	7	17	10	14	6	10
4	15	7	21	8	6	11	18	11	12	12
5	18	12	20	7	9	15	21	10	4	8
6	11	10	14	12	10	14	14	22	8	4
7	7	7	10	13	8	12	11	28	10	2
8	14	5	12	10	7	19	10	17	3	1
9	8	9	8	9	5	10	16	24	14	7
10	13	13	19	11	6	16	8	20	9	9
$\sum Xij$	142		147		77		140		81	
$\sum Yij$		92		99		132		173		66
SP*xy*	332		296.5		189.1		484		156.7	
r_k	0.637		0.696		0.648		0.634		0.680	
t	2.33		2.74		2.40		2.31		2.48	
r_{nt}	0.778		0.821		0.787		0.776		0.809	
Students	Variant VI		Variant VII		Variant VIII		Variant IX		Variant X	
xi, yi	*x*6	y6	*x*7	y7	*x*8	y8	*x*9	y9	*x*10	y10
Рэij	6	11	16	13	7	10	18	16	10	11
1	5	7	11	10	7	10	7	8	8	3
2	4	8	15	6	3	5	11	9	9	4
3	2	4	10	13	4	8	8	11	3	2
4	5	3	7	11	6	4	13	12	4	1
5	3	9	12	8	5	9	17	6	5	8
6	4	10	9	9	2	7	10	5	7	4
7	6	8	13	12	5	6	12	4	10	5
8	4	11	16	7	2	10	15	10	6	2

9	1	7	14	5	5	9	16	7	7	3
10	3	10	10	7	4	8	7	3	8	9
$\sum Xij$	37		117		42		116		64	
$\sum Yij$		77		88		76		75		41
SP*xy*	64.8		215		73.4		212.7		81.6	
r_k	0.642		0.652		0.677		0.703		0.672	
t	2.37		2.43		2.6		2.79		2.56	
r_{nt}	0.782		0.789		0.808		0.826		0.804	

From the formula (11) we see that the received reliability coefficient is 0,8 that satisfied the range from 0,7 to 0,9 and showed the sufficient reliability of the tests.

The criterion of test validity was the most important criterion for the assessment of the results received at different investigation stages.

The obtained results show that the created test tasks to the course «Basis of Electrophysical and Electrochemical Methods of Processing of Materials» comply with the necessary criteria: validity, simplicity, definiteness, unambiguity, objectivity, efficiency and reliability.

6. Conclusion

Basing on the results of the experimental pilot study we can draw the following conclusions:

- the obtained data proves the efficiency of the applied technique of training students majoring in «Technological education» in comparison with the traditional one (on the example of the created course «Basis of Electrophysical and Electrochemical Methods of Processing of Materials»);

- while using the active methods of teaching students (the problem and research methods, laboratory workshops with the use of the created didactic teachware (the high-tech educational laboratory equipment based on digital technologies with program control (electrospark, high-frequency electrospark processing and processing of materials by currents of high frequency) we could solve the problems of providing the technical and technological problem content with the use of testing for determining the level of the students' acquisition of the basic concepts of the course «Basis of Electrophysical and Electrochemical Methods of Processing of Materials» that promoted the improvement of the quality of vocational scientific and technological training of the students majoring in «Technological education» in IHL.

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