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Estimation of the Testing of Students and Their Static Treatment Using a New Software Complex for Adapted Testing.

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ABSTRACT: This article describes the processing of the results of mathematical statistics of students' knowledge using Adaptive testing software.

KEY WORDS: adaptive tests, mean value, standard deviation, experimental frequency, theoretical frequency.

I.INTRODUCTION

Adaptive test control and adaptive learning are a modern computer version of the implementation of the well-known pedagogical principle of individualization of education, one of the most important for the preparation of qualified specialists. This principle could not be implemented in any effective manner in the context of traditional class-lesson forms of classes — lecture and group. In the modern version, adaptive forms appeared recently as a result of the interrelation of three progressive trends: computerization of education, the increasing role of autodidactics and the development of the theory of pedagogical measurements [1,2].

Computerization of education makes it possible to reduce the unproductive costs of the living work of teachers, to preserve the methodological potential of professors of the older generation, to reuse the results of materialized labor in the form of computer training and monitoring programs. It can also help teachers transform from the lessor to the technologist of the modern educational process, in which the leading role is given not so much and not only to the teaching activity of the teacher, but to the teaching of the students themselves.

The feasibility of adaptive control arises from considerations of rationalization of traditional testing. A trained student does not need to give easy tasks, because the probability of their correct solution is high. Lightweight materials do not have a noticeable developmental potential, while difficult tasks for most students reduce learning motivation. Symmetrically, due to the high probability of a wrong decision, there is no point in giving difficult tasks to a weak student. The use of tasks corresponding to the level of preparedness significantly increases the accuracy of measurements and minimizes the time of individual testing to about 5-10 minutes. Adaptive training allows you to ensure that training tasks are issued at the optimal 50% difficulty level [3].

II. RESEARCH METHOD

Since the adaptive test itself is a version of an automated testing system in which the parameters of difficulty and the differentiating ability of each task are known in advance. This system is created in the form of a computer bank of tasks, ordered according to the characteristics of the tasks. The most important characteristic of the tasks of the adaptive test is the level of their difficulty obtained experimentally, which means: first get to the bank, each task must be empirically tested on a sufficiently large number of subjects [4,5]. To this end, in our opinion, it is convenient to use the method of invariant test items, which are easily fed to the variation in both form and content [6] using the new method and tools developed by us [7].

This software package is designed to develop students' creative activity with targeted use of invariant test items with guaranteed quality indicators, providing an objective assessment of knowledge and motivating students, without the participation of an examiner, and serves to create distance learning technology and adaptive testing.

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The program complex creates the possibility of processing the experimental results given in educational and research centers with predetermined accuracy. The results of digital signal processing in the form of a graph and a table of compression ratios.

III. THE RESULT OF THE STUDY

As a result of experiments, observations and gathering information about the phenomenon of interest to us, statistical material accumulates, i.e. A set of values for one or more parameters, usually in a chaotic state. This is the so-called unordered variation series of values. Information was gathered about the students' knowledge, and such an unordered variation series of values was obtained by their examinations by statements. Total data obtained for 116 students:

10	16	21	13	17	9	16	25	17	20	17	14	17
18	15	18	15	15	10	11	16	19	17	13	14	13
21	10	15	12	14	16	17	12	21	17	14	17	14
10	17	18	18	14	13	23	17	22	13	16	18	24
11	23	10	17	14	18	16	17	17	17	22	18	25
17	19	20	11	21	18	14	22	21	20	24	15	21
22	18	19	19	14	19	20	16	11	12	11	9	
15	10	19	15	16	20	18	17	16	17	17	18	
24	15	22	19	21	8	19	24	13				
19	21	17	21	10								

This random set of numbers must be put in a certain order. To do this, first of all, it is necessary to determine the smallest and largest values of the evaluation points. In this example, this is 0 point and 30 point. The difference between these values is called the range of the variation series R = 30 points. [8]

The next processing operation is to divide the variation series into intervals. Usually almost the number of intervals is chosen 5-12, but you can determine the number of intervals by an approximate formula.

$$K = 1 + 3{,}3 \log N$$

Where N is the sample size, i.e. the number of available values of the trait.

In our example, K = 6. Since the span of R = 30, the width of the interval h = 3.75 It should be noted, however, that the above formula for the number of intervals does not always give a successful number. Sometimes he uses the formula or even selects the number of intervals without any calculation within the above limits.

From the set of values of attributes, their number is calculated, which fall into each interval, putting in the corresponding line of table 1. The strokes must be grouped into five units so that it is more convenient, then counted. This frequency table should have six columns:

№ interval	Border spacing	Mid interval	Frequency		Frequency
			Strokes	Number	
1	2	3	4	5	6
1	1-5	2,5		0	0,0000
2	6-10	7,5	IIIIIIIIII	10	0,0000
3	11-15	12,5	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	31	0,1293
4	16-20	17,5	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	53	0,2241
5	21-25	22,5	IIIIIIIIIIIIIIIIIIIII	21	0,3362
6	26-30	27,5	I	1	0,2414
				116	1,000

Further processing of the variation series consists in calculating the average value of the attribute or reliability index and the dispersion characteristic around this average value, i.e. standard deviation or standard values. The calculation is carried out according to the formulas, the type of which depends on the number of observations or the sample size.

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If the sample is small N <30, then calculations are carried out on unweighted values of the mean and standard deviation; if the sample size is significant, i.e. N> 30 then the calculation takes into account the average values of the intervals of the variation series and their weight. A summary of the formulas for calculating the mean and standard deviation are shown in Table 2.

№	Indicators of variation range	Small sample N <30	Large sample N> 30
1	Mean value $\overline{X}$	$\overline{X}=\frac{1}{N}\sum_{i=1}^{N}X_i$	$\overline{X}=\frac{1}{N}\sum_{i=1}^{N}X_{cpi}\,m_{эi}$
2	Standard deviationS_X	$S_X=\sqrt{\frac{1}{N-1}\sum(X_i-\overline{X})^2}$	$S_X=\sqrt{\frac{\sum_{i-1}^{N}X_{cpi}^2 m_{эi}}{N}-\overline{X}^2}$
Note: in the formula of the table: K is the number of intervals of the variation series; X_{cpi} - the average value of the interval; $m_{эi}$– experimental frequency of the i -th interval			

An important characteristic of the dispersion of random variables, including reliability indicators, is its relative value, i.e. coefficient of variation, which is calculated by the formula:

$$V=\frac{S_X}{\overline{X}}$$

Having the data in Table 1, you can build a histogram of the distribution of the studied reliability index, for example, as in the example above, the reliability of the tests. For this, the values of the exponent and the boundaries of the intervals of the variational series are plotted on the abscissa axis, and the frequency mei or frequency in absolute values or in percentages is plotted along the ordinate axis. Rectangles are built on each interval, the height of which is equal to the frequency or frequency in this interval.

The histogram for the given example of the variation series is built in Fig.1. apparently, it has a fairly regular symmetric shape [8,9].

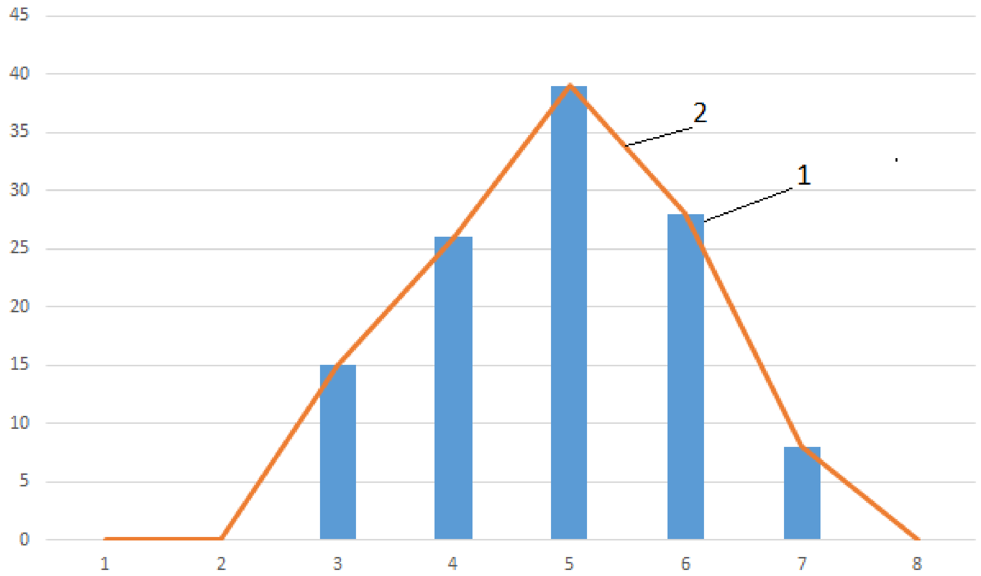

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Fig.1. The histogram, the distribution of the more experienced frequency (1) and a flattening curve of the theoretical curve (2).

The obtained histogram is approximated by a curve of the theoretical distribution law of a random variable. This is necessary to accomplish in order to obtain a more general distribution, which could be extended to the entire set of objects studied. In addition, the creative laws of distribution are well studied, so they can be used to more fully characterize the studied reliability indicators.

The most common in the theory of reliability are the law of normal distribution, the Weibull law, the exponential law, and some others. The choice of the most appropriate theoretical distribution law is made by the appearance of the histogram and the magnitude of the coefficient of variation. Close to symmetric histograms and when most likely approximated by a normal law. Constantly decreasing histograms with V = 1 indicate an indicative law. The Weibull distribution law is usually best suited for asymmetric histograms at V = 0.5 ... 0.7 [9].

When choosing a theoretical distribution law, it is necessary to take into account the physical nature of the phenomenon being studied, the observation of which gave a variation series of values of the indicator.

If observations were made of gradual object failures caused by a series of independent causes and the influence of many random factors, then the normal distribution law should be used; distribution of failures due to aging of materials are in good agreement with the Weibull law. The combined effects of aging and wear lead to the distribution of failures close to the log-normal law. Distributions of sudden failures are in good agreement with the indicative law.

To verify the correctness of the choice of the theoretical distribution law, it is necessary to calculate the so-called compliance criteria, which indicate the degree of discrepancy between the theoretical and experimental frequencies or frequencies. For each distribution law considered further, specific instructions will be given on determining the criteria for compliance.

Data processing according to the normal distribution law

The appearance of the histogram in the example of section 1 shows that it can be approximated by a normal distribution curve, the formula for which is as follows:

$$f(L) = \frac{N * \Delta L}{S_L \sqrt{2\pi}} e^{-\frac{(L-\bar{L})^2}{2S_L^2}}$$

To calculate the parameters of the normal distribution and build its theoretical curve, table 3 is compiled.

Definitions of the sample mean i. average student knowledge:

$$\bar{L} = \frac{\sum_{i=1}^{k} L_i m_{эi}}{N} = 16.29$$

Since N> 30, the calculation of the standard deviation is carried out according to the uncorrected formula:

$$S_L = \sqrt{\frac{\sum_{i=1}^{k} L_i^2 m_{эi}}{N} - \bar{L}^2} = 4.39$$

Knowing the mean value and standard deviation for each interval, we determine the value of the parameter and fill in the column of the 7th table 3.

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Table 3

№interval	MidintervalL_{cpi}	Experimentalfrequency $m_{эi}$	$L_{i*} m_{эi}$	$L^2_{i*} m_{эi}$	$L_i - \bar{L}$	Parameter $t = \frac{L_i - \bar{L}}{S_i}$	Normalizedfunction$f(t)$	Theoretical		Accumulated frequencies		Frequencydifference
								Frequency, m_{Ti}	Frequency, $m^э_{Ti}$	Experimental	Theoretical	
1	2	3	4	5	6	7	8	9	10	11	12	13
1	2,5	0	0,0000	0	0	-13,79	0,0029	0	0,0033	0	0	0
2	7,5	10	0,0862	75	562,5	-8,79	0,0538	7	0,0613	10	7	3
3	12,5	31	0,2672	387,5	4843,8	-3,79	0,2763	37	0,3150	41	44	-3
4	17,5	53	0,4569	927,5	16231	1,21	0,3867	51	0,4409	94	95	-1
5	22,5	21	0,1810	472,5	10631	6,21	0,1475	19	0,1682	115	114	1
6	27,5	1	0,0086	27,5	756,25	11,21	0,0153	2	0,0175	116	116	0
		116	1,0000	1890	33025			116	1,000			

According to the obtained values of t in the table of the normalized function f (t), we determine its values (entered in column 8).

Now we determine the constant coefficient in the density formula for the normal distribution, equal to:

$$\frac{N * \Delta L}{S_L} = \frac{116 * 5}{4,39} = 132.1$$

Where ΔL is the width of the interval of the variation series.

We multiply the values of the normalized function (column 8) by the value of this coefficient and put the result in column 9, rounding it to an integer - these will be the theoretical frequencies mti, and divided by their sum, i.e. Σm_T will have theoretical frequencies in column 10.

Having in table 3 the values of the experimental and theoretical frequencies of the normal distribution of operating time, it is possible to calculate the agreement criteria for checking the correctness of the choice of the theoretical distribution that approximates the empirical histogram.

Consider the three criteria of consent.

a) Pearson Consensus Criteria [10,11] or χ2. This criterion represents the sum of the squares of the deviations of the theoretical frequencies from those experienced in each interval, referred to the theoretical frequency in this interval.

$$\chi^2 = \sum_{i=1}^{k} \frac{(m_{эi} - m_{Ti})^2}{m_{Ti}}$$

When calculating according to this formula, it should be borne in mind that the absolute frequency in the interval should be at least five, therefore, with its smaller values, adjacent intervals should be combined. In our example,

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the first and last intervals have an absolute frequency equal to three, so these intervals are combined: the first in the second and sixth with the seventh. Thus, in the calculation is taken K = 4

According to the table, the probability P (χ2) of coincidence of the experimental and theoretical frequencies is determined, which should be as close as possible to unity. To determine it, it is necessary to know the number of degrees of freedom, which is equal to:

$$\tau = K - П_{св} - 1 = 4 - 2 - 1 = 1$$

$$\chi^2 = \sum_{i=1}^{k} \frac{(m_{эi} - m_{Ti})^2}{m_{Ti}} = \frac{(0-0)^2}{0} + \frac{(10-7)^2}{7} + \frac{(31-37)^2}{10} + \frac{(53-51)^2}{51} + $$

$$+ \frac{(21-20)^2}{20} + \frac{(1-2)^2}{2} = 3{,}26$$

According to the proposed formula, the probability values

P (χ2) = 0.31

It is known [10,11] that for P (χ2) <0.3, i.e. at 30% probability of discrepancy is considered significant and the law of normal distribution cannot be used

Thus, in our example, we obtained a condition P (χ2)> 0.30 satisfying that the discrepancy between the theoretical and experimental frequencies is insignificant and we can accept the curve of the law of normal distribution for smoothing experienced histograms.

b) The consent criteria of Professor Romanovsky [10,11]. For its calculation, the ratio $\frac{|\chi^2 - \tau|}{\sqrt{2\tau}}$ is determined, where τ - is the number of degrees of freedom.

If the indicated ratio in absolute value is less than two, then the discrepancy between the theoretical and experimental frequencies can be considered insignificant and a normal distribution law can be adopted. For the applied Romanovsky criterion is

$$\frac{|3{,}26 - 2|}{\sqrt{2 \cdot 2}} = 0.63$$

those. less critical (0.63 << 2)

c) The consent criteria of Academician Kolmogorov [10,11] establish the closeness of theoretical frequencies by an experimental method of comparing their integral distribution functions. The calculation of the criterion λ is carried out according to the formula

$$\lambda = \frac{D}{\sqrt{N}}$$

where *D* is the maximum value of the modulus of the difference of the accumulated theoretical experimental frequencies, *N* is the sample size (the number of observations)

in our example, the value *D* = 3 and therefore, the criterion λ is equal to:

$$\lambda = \frac{3}{\sqrt{116}} = 0.28$$

In the probability table P (λ), we find the corresponding value. P (λ) = 0.9983, which means that the discrepancies between the theoretical and experimental frequencies are random and the curve of the law of normal distribution approximates the experimental histogram well.

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IV. CONCLUSION

Thus, we can conclude that all three criteria of agreement gave us when checking our results. This is an evidence of the correctness of the complex program developed by us and the reliability of the results obtained. Further development of the method requires testing it in various academic disciplines of educational systems.

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