The traditional teaching-learning method versus multimedia technology. Using the Wilcoxon test and the Gauss repartition

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THE TRADITIONAL TEACHING-LEARNING METHOD VERSUS MULTIMEDIA TECHNOLOGY. USING THE WILCOXON TEST AND THE GAUSS REPARTITION

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Abstract. This article highlights the ways of applying various statistic methods with the purpose of comparing modern teaching methods, which are based on the implementation of information technology, with the traditional teaching methods, tested, for a period of two years, in parallel groups: experimental and control groups.. Thus, the Wilcoxon (T) test is used for processing data in case of exams and a creativity task within the experimental and the control groups. This test applies in case of comparing ordinal dependent values and is used with the purpose of determining the correlation of indexes, within one and the same selection, measured in two distinct situations. Outlining the results is done with the help of Guassian comparative curves for both groups (experimental and control).

Keywords: test, creativity task, experimental group, control group, Wilcoxon test, Gauss distribution

The Wilcoxon test

„The Wilcoxon test statistic is based on the study of differences which appear between a couple of observations, taking into consideration both the sign of the differences, and their absolute values" [0]. Let us consider two independent series of data:

$$X;x1,x2,\dots,xn$$
$$Y;y1,y2,\dots ym \qquad (1)$$

which are extracted from two correlated samples, of size n, which characterize the stages of independent values, generated by the first (series X) and the second (series Y) measurement, within the experimental and control groups.

Considering : X- the test results from the experimental groups; Y – the test results in the control groups; Di – the result of the subtraction (Di=Xi –Yi); Ri- the rank of the subtraction; | Ri |- the absolute value of the rank of the subtraction.

The application of the Wilcoxon(T) test for the processing of data, regarding the completion of the test, is done as follows:

a) The validation hypotheses are elaborated:

- The Null Hypothesis H0: Di=0, (the equality of the distributions) the repartition of the measured index for the experimental group and the repartition of the measured index for the control group in the case of both examinations is the same, which means that the changes by means of increases in grades are purely random;
- The Alternative Hypothesis H1: Di≠0 (distributions are distinct), which means that the distribution laws of the index are different and that the increase of the grades as a result of applying multimedia technology in the teaching-learning process are predictable.

b) The test statistic is obtained by following these steps:

1. The observed differences are calculated;

Experimental Group	*Control Group*	*Difference*
x_1	y_1	$x_1 - y_1$
x_2	y_2	$x_2 - y_2$
....	**....**	**....**
x_n	y_n	$x_n - y_n$

Table 1. Observed Differences

3. null results are eliminated and the following series is obtained: d1, d2, ...dk, with $k \leq n$;
4. the series of non-null results in absolute value is sorted ascending: $|d1| \leq |d2| \leq ... \leq |dk|$;
5. ranks are attributed to the series obtained, following the procedure of the Mann-Whitney test;
6. the sum of ranks corresponding to the initial positive differences (T+) and the sum of the ranmks corresponding to negative differences (T-) are calculated;
7. the T test statistic is the minimal value of the two sums calculated within step 5:

$$T=min(T+ ,T-). \quad (2)$$

The decision in the test involves the following [0]:

b) In the case of the bilateral test: the H0 hypothesis is rejected in favor of H1, if the calculated value is smaller or equal to the critical value for the bilateral test;

c) In case of applying the the one-sided test: the H0 hypothesis is rejected in favor of H1, if the calculated value is smaller or equal to the critical value for the one-sided test.

In case of smaller sizes of the samples (n<27), the critical values for the Wilcoxon test are outlined in correspondent table [4]

The statistic data for testing the experimental and control groups, processed with the aid of the Wilcoxon criterion, are outlined in table 2

No.	Grade exper. group	Grade control group	Difference Di=Xi-Zi	Absolute value of difference	Rank of the absolute value of the difference
1	5.67	6.00	-0.33	0.33	1.5
2	7.67	7.33	0.33	0.33	1.50
3	8.67	8.00	0.67	0.67	3.50
4	9.33	8.67	0.67	0.67	3.50
5	8.67	7.67	1.00	1.00	5.50
6	6.00	7.00	-1.00	1.00	5.50
7	9.67	8.33	1.33	1.33	7.50
8	7.33	6.00	1.33	1.33	7.50
9	6.33	4.67	1.67	1.67	10.50
10	10.00	8.33	1.67	1.67	10.50
11	8.00	6.33	1.67	1.67	10.50
12	8.33	6.67	1.67	1.67	10.50
13	8.67	6.67	2.00	2.00	13.50
14	9.00	7.00	2.00	2.00	13.50

No.	Grade exper. group	Grade control group	Difference Di=Xi-Zi	Absolute value of difference	Rank of the absolute value of the difference
15	10.00	7.33	2.67	2.67	15.50
16	7.00	4.33	2.67	2.67	15.50
17	10.00	7.00	3.00	3.00	17.00
18	9.67	5.67	4.00	4.00	18.50
19	8.00	4.00	4.00	4.00	18.50
20	5.00	9.33	-4.33	4.33	20.00
21	10.00	5.00	5.00	5.00	21.00
Sum of ranks					**231**

Table 2. Statistic data for the experimental and control groups, in the case of the test, processed with the aid of the Wilcoxon criterion

Performing the calculations:

1. The sum of the ranks is calculated and must coincide with the one calculated according to formula:

$$\sum R_i = \frac{21*22}{2} = 231 \tag{3}$$

2. The T+ şi T- statistics are calculated:

- Lista The T+ statistic (the sum of ranks corresponding to the positive differences) equals 204 (T+=204).
- The T- statistic (the sum of ranks corresponding to the negative differences) equals 27 (T-=27).

The T statistic is the minimal value of the two calculated sums:

$$T=min(T+ ,T-)=27 \tag{4}$$

The decision in the test:

The Wilcoxon statistic is T=27. The table of critical values shows for the bilateral test, for a sample size for n=21, the value of T*=58 for the significance level α=0.05.

Because T<T*(the calculated value is smaller than the critical value), the null hypothesis regarding the equality of distributions is rejected. Therefore, the alternative hypothesis is valid, which means that the distributions of the index are distinct in the first and second measurement and that the increase of the grades as a result of applying multimedia technology in the teaching-learning process are predictable.

The statistic data for the creativity task for the experimental and control groups, processed with the aid of the Wilcoxon criterion, are outlined in table 3.

No.	Grade exper. group	Grade control group	Difference Di=Xi-Zi	Absolute value of difference	Rank of the Absolute value of the difference	Symbol (+ /-)
1	7	6	1	1	3	+
2	6	7	-1	1	3	-
3	8	7	1	1	3	+
4	6	7	-1	1	3	-
5	9	10	-1	1	3	-
6	8	6	2	2	7.5	+
7	8	6	2	2	7.5	+
8	8	6	2	2	7.5	+
9	10	8	2	2	7.5	+
10	10	7	3	3	12	+
11	8	5	3	3	12	+
12	9	6	3	3	12	+
13	7	4	3	3	12	+
14	10	7	3	3	12	+
15	9	5	4	4	16	+
16	8	4	4	4	16	+
17	9	5	4	4	16	+
18	10	5	5	5	19.5	+
19	10	5	5	5	19.5	+
20	10	5	5	5	19.5	+
21	9	4	5	5	19.5	+
Sum of ranks					**231**	

Table 3. The statistic data for the creativity task for the experimental and control groups, processed with the aid of the Wilcoxon criterion

Performing the calculations for the T criterion:

- The T+ statistic (the sum of ranks corresponding to the positive differences) equals 222 (T+ =222)
- The T- statistic (the sum of ranks corresponding to the negative differences) equals 9 (T- =9).

The decision for the test is similar to the one in item 2. and is performed similarly.

The Wilcoxon statistic is T=9. The table of critical values shows for the bilateral test, for a sample size of n=21, the value of T*=58 for the significance level α=0.05.

The test decision: Because T<T*(the calculated value is smaller than the critical value), the null hypothesis regarding the equality of distributions is rejected. Therefore, the alternative hypothesis is valid: the

distributions of the index measured for the first population is situated more to the right, which means that the proposed methodology is more efficient.

The Gauss repartition

The outline of the results is elaborated with the aid of histograms in which the horizontal axis represents the grading intervals and the vertical axis symbolizes the frequencies (the number of students within the respective grading interval) and the Gaussian comparative curves [5] for both groups (control and experimental).

We have defined the grading intervals as follows: exceptional – 10; very good – [9..10); good – [8..9); mediocre – [7..8); poor – [6..7); very poor – [5..6); – [4..5).

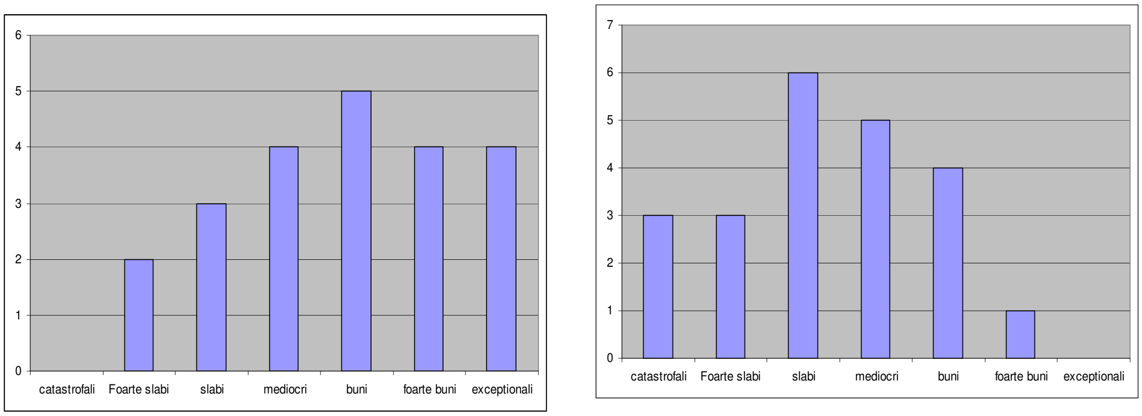

Fig. 1. Histogram of the test results obtained by the students in the experimental group and the control group

By transforming the histograms in Gaussian probability curves, we can compare the obtained results. The bigger the size of the sample, the more the curve will come closer to resembling the "ideal" form. In case of the experiment conducted for the two groups we obtain the following graphs (see fig. 2).

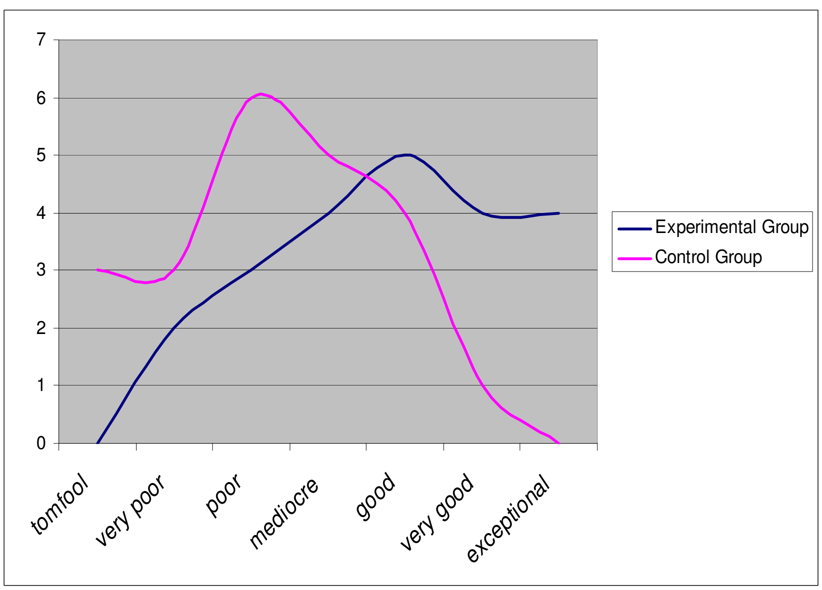

Fig. 2 Gaussian comparison curves obtained after testing

Within the experimental groups, in the case of the test, the average value is 8.14, and for the control groups, the value is 6.62. If the results obtained by the experimental groups are compared to those obtained by the control groups, it is obvious that the maximal value of the experimental sample is placed between grades 8-9, and the maximal value for the control sample between grades 6-7.

By analyzing the Gaussian comparison curves we notice a movement of the maximal value towards the right, which corresponds to a real progress of the students resulting from the assimilation of information through multimedia courses.

Through numerous practical applications, the normal Gaussian distribution has a distinct importance in metrology. With its aid, the following can be analyzed:

- a series of measurements, strictly under the same experimental conditions, performed on the same X value;
- the results of some measurements on a collection of objects characterized by a certain trait, in order to determine a certain characteristic of the collection.

Conclusions

We have outlined data processing with the aid of statistic tests, applied in the evaluation of the results of the educational experiment. Based on the criteria used and the verified hypotheses, we can state the following, in conclusion:

- the overall analysis of the mathematical and statistical evaluations indicates a satisfactory progress for the students in all the groups involved in the research experiment;
- applying the elaborated methodology contributes to the amplification of the efficiency of the teaching-learning process and offers training possibilities that take into consideration the individual characteristics of every student;
- the implementation of multimedia courses contributes to information assimilation, by applying knowledge in the creative process
- computer assisted training has a as a result an increase in the quality of data acquisition.
- by applying the multimedia courses in the process of teaching-learning all subject matters, we amplify the interest of the students towards the respective subject matters.

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