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Utilization of Statistical Methods in Educational Research

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Abstract

Statistical methods play a key role in educational research. This paper focuses on the significance and application of statistical methods in educational research, demonstrating how these methods can be used to examine the effectiveness of different teaching methods, evaluate educational interventions, and identify factors influencing learning. Basic statistical procedures, such as statistics, correlations, regression analyses, t-tests, and statistical hypotheses are discussed. The paper also highlights common errors in the use of statistical methods and stresses the importance of carefully selecting appropriate statistical tools. The aim is to provide educators and researchers with a practical overview.

Keywords: statistical method, educational research, regression, hypothesis, result

Introduction

Statistical methods play a crucial role in educational research because they allow for the objective analysis and interpretation of data gathered from studying educational processes, interventions, and outcomes. They enable researchers to test hypotheses, compare groups, identify relationships between variables, and uncover factors influencing education. Methods such as t-tests, correlation analyses, regression analyses, and ANOVA are commonly used to evaluate the effectiveness of teaching methods, improve educational programs, and support decision-making in education.

ANOVA (Analysis of Variance)

ANOVA is a statistical method used to test differences between three or more groups. Its main goal is to determine if there are significant differences between the means of these groups. ANOVA compares variability between groups with variability within groups to decide whether the observed differences are not just due to chance. This method is commonly used in experimental research, such as in education, psychology, or when testing the effectiveness of various treatment methods (Heiman, 2006).

Use of T-test in Educational Research

A T-test is a statistical tool used in educational research to compare the means of two groups to determine if there is a statistically significant difference between them. This method is frequently applied to evaluate the effectiveness of teaching methods, programs, or interventions in education. For example, a T-test can compare students' test results who participated in different instructional activities to determine if one method yields better outcomes than the other. It helps educators and researchers verify if the observed differences are not merely by chance (Chraska, 2016).

Use of Regression and Correlation Analysis in Educational Research

Regression and correlation analysis are statistical methods used in educational research to explore relationships between variables. Correlation analysis measures the strength and direction of the relationship between two variables, such as the relationship between study time and academic performance. It helps to identify associations but does not establish causality. Regression analysis takes this further by examining how one or more independent variables affect a dependent variable, allowing for predictions, such as how different teaching methods impact student success. Both methods are commonly employed to identify key factors influencing education and to better understand the effectiveness of teaching approaches.

Use of PAST Software in Educational Research

The PAST (PAleontological STatistics) software is a free statistical tool that is also used in educational research for data analysis. It offers a wide range of statistical methods, including basic descriptive statistics, correlation and regression analysis, ANOVA, t-tests, cluster analysis, and more as can be seen in (Krpec, 2013). Thanks to its user-friendly platform, it is ideal for researchers, educators, and students who need to quickly and efficiently analyze data. It aids in assessing the effectiveness of teaching methods, studying the influence of various factors on learning, and other educational research activities (Fraenkel, 1993).

Practical examples of calculations in statistical research

Practical examples of calculations in statistical research often involve data analysis using various statistical methods. Here are three examples:

T-test: Used to compare the means of two groups. For example, in research on the effectiveness of two teaching methods, it tests if the differences in student outcomes are statistically significant.

ANOVA (Analysis of Variance): Used to compare more than two groups, such as examining the average test scores of students from different schools.

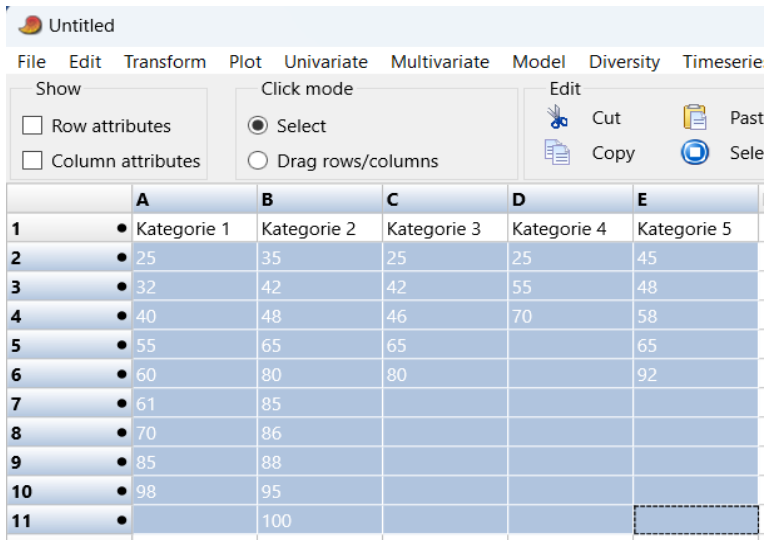
Regression and Correlation Analysis: Evaluates the relationship between a dependent and independent variable, like the impact of study hours on grades. Each method has unique uses and interpretations, allowing for a detailed understanding of data patterns in pedagogical research.

Using the ANOVA method in a pedagogical example

32 master's students in the Teaching of Vocational Subjects program took a test scored from 0 to 100 points. The test focused on concepts related to social sciences. The students were divided into five categories:

1. Category: Primary School Teachers.
2. Category: Secondary School Teachers.
3. Category: Government Employees.
4. Category: Private Sector Employees.
5. Category: Security Forces and Emergency Services Employees.

Points in the first category: 25, 32, 40, 55, 60, 61, 70, 85, 98 (9 students), Points in the second category: 35, 42, 48, 65, 80, 85, 86, 88, 95, 100 (10 students), Points in the third category: 25, 42, 46, 65, 80 (5 students), Points in the fourth category: 25, 55, 70 (3 students), Points in the fifth category: 45, 48, 58, 65, 92 (5 students).



	A	B	C	D	E
1	Kategorie 1	Kategorie 2	Kategorie 3	Kategorie 4	Kategorie 5
2	25	35	25	25	45
3	32	42	42	55	48
4	40	48	46	70	58
5	55	65	65		65
6	60	80	80		92
7	61	85			
8	70	86			
9	85	88			
10	98	95			
11		100			

Figure 1. Inputting data into the PAST program

Determine if there is a significant relationship between the test scores and the employment category of the students.

To solve this task, use the ANOVA (Analysis of Variance) statistical method.

Verifying pedagogical data for normality using the PAST program as can be seen in Figure 1:

1. Testing data for normality, α = 0.05, "p" calculated value.
2. Normality condition of the data: p > α.

Shapiro-Wilk W, see Figure 2: 0.8962 > 0.05, 0.1827 > 0.05,

0.9101 > 0.05, 0.6369 > 0.05, 0.3389 > 0.05, normality is fulfilled for all data categories.

Anderson-Darling A, see Figure 2: 0.9026 > 0.05, 0.1591 > 0.05, 0.8102 > 0.05, 0.4867 > 0.05, 0.3203 > 0.05 – normality is fulfilled for all data categories.

Tests for normal distribution

	A	B	C	D	E
N	9	10	5	3	5
Shapiro-Wilk W	0,9702	0,8929	0,9757	0,9643	0,8863
p(normal)	0,8962	0,1827	0,9101	0,6369	0,3389
Anderson-Darling A	0,1692	0,4988	0,1846	0,2296	0,341
p(normal)	0,9026	0,1591	0,8102	0,4867	0,3203
p(Monte Carlo)	0,939	0,1622	0,9003	0,6278	0,363
Lilliefors L	0,1241	0,2278	0,2036	0,253	0,2281
p(normal)	1,179	0,1451	0,7117	0,652	0,5361
p(Monte Carlo)	0,9554	0,1568	0,7468	0,6337	0,5418
Jarque-Bera JB	0,3832	1,091	0,3174	0,3541	0,7245
p(normal)	0,8256	0,5796	0,8533	0,8377	0,6961
p(Monte Carlo)	0,7752	0,2135	0,829	0,6244	0,2104

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Figure 2. The calculated significance level "p" values for normality

Results of the ANOVA testing method:

Using the PAST program, the selected ANOVA method applies the following conditions:

1. If p > α, the alternative hypothesis H1 is rejected.
2. If p < α, the null hypothesis H0 is rejected.

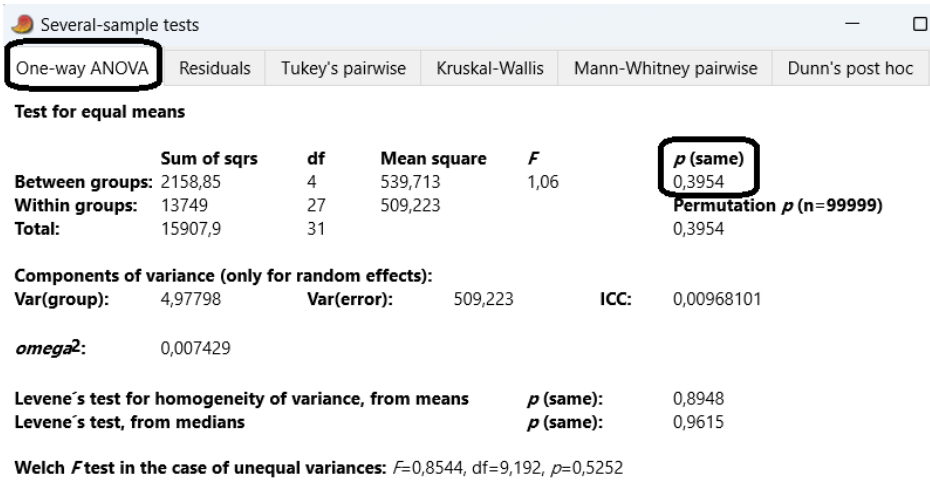


Figure 3. Calculated "p" value for ANOVA

Formulation of hypotheses:

Hypothesis H_1: $p < \alpha$, There is a statistically significant relationship between the test score results and the employee categories at the significance level $\alpha = 0.05$.

Hypothesis H_0: $p > \alpha$, There is no statistically significant relationship between the test score results and the employee categories at the significance level $\alpha = 0.05$.

Conclusion of ANOVA testing: $\alpha = 0.05$, $p = 0{,}3954$, see Figure 3. Since $p > \alpha$, we accept hypothesis H_0. Based on the ANOVA results, we reject the alternative hypothesis H_1 in favor of the null hypothesis H_0. This suggests there is no significant relationship between the test scores and the employee categories.

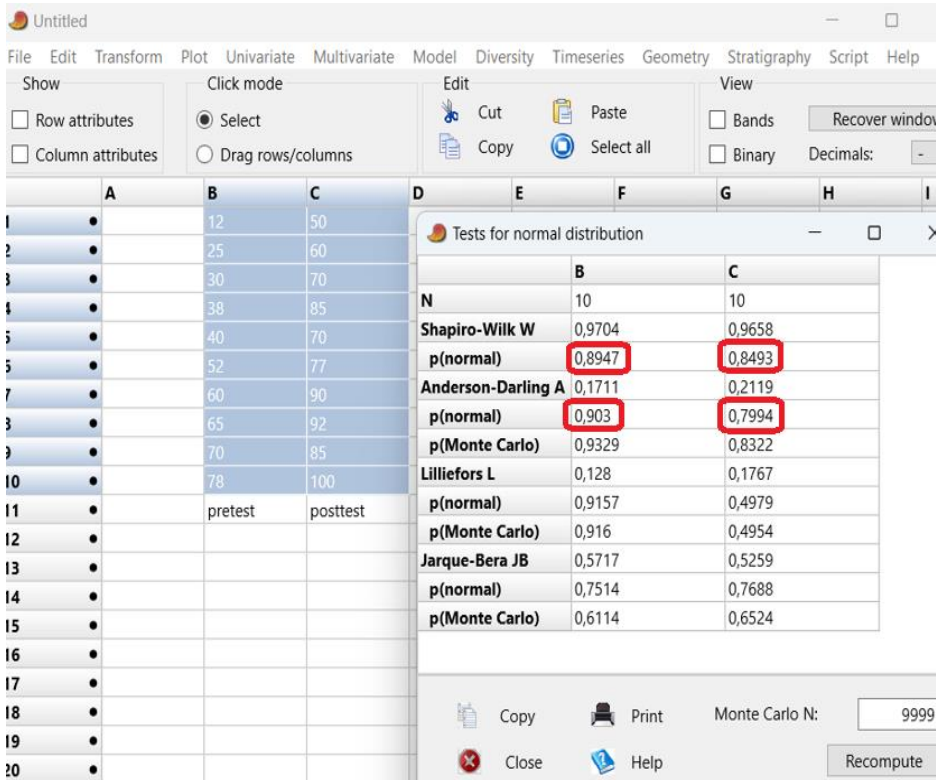
Use of the T-test in Educational Research

We can best illustrate the use of the T-test with an example. Ten students wrote a pretest on statistical concepts at the beginning of the semester with scores of 12, 25, 30, 38, 40, 52, 60, 65, 70, and 78 (maximum 100 points). After completing the semester, the same group wrote a post-test with scores of 50, 60, 70, 85, 70, 77, 90, 92, 85, and 100.

Evaluate the knowledge improvement after the semester using a T-test and the PAST statistical program.

Results of the T-test:

1. Testing data for normality, $\alpha = 0{,}05$, "p" – calculated value.
2. Normality condition of the data: $p > \alpha$ (Rudolf, 2021).



	A	B	C
1		12	50
2		25	60
3		30	70
4		38	85
5		40	70
6		52	77
7		60	90
8		65	92
9		70	85
10		78	100
11		pretest	posttest
12			
13			
14			
15			
16			
17			
18			
19			
20			

	B	C
N	10	10
Shapiro-Wilk W	0,9704	0,9658
p(normal)	0,8947	0,8493
Anderson-Darling A	0,1711	0,2119
p(normal)	0,903	0,7994
p(Monte Carlo)	0,9329	0,8322
Lilliefors L	0,128	0,1767
p(normal)	0,9157	0,4979
p(Monte Carlo)	0,916	0,4954
Jarque-Bera JB	0,5717	0,5259
p(normal)	0,7514	0,7688
p(Monte Carlo)	0,6114	0,6524

Figure 4. Pretest and Posttest Score Input and Normality Results

Verification of educational data for normality in PAST software:

1. Normality testing, $\alpha = 0.05$, "p" – calculated value.
2. Normality condition: $p > \alpha$.

Shapiro Wilk W, see Figure 4:

$0.8947 > 0.05$, $0.8493 > 0.05$ normality is satisfied for both data categories.

Anderson Darling A, see Figure 4:

$0.903 > 0.05$, $0.7994 > 0.05$ normality is satisfied for both categories.

PAST program using the T-test method:

1. If $p > \alpha$, the alternative hypothesis H1 is rejected.
2. If $p < \alpha$, the null hypothesis H0 is rejected.

Hypotheses as can be seen in Figure 5:

1. H1: $p < \alpha$, statistically significant paired differences exist between pretest and posttest scores.
2. H0: $p > \alpha$ No statistically significant paired differences exist between pretest and posttest scores at $\alpha = 0.05$.

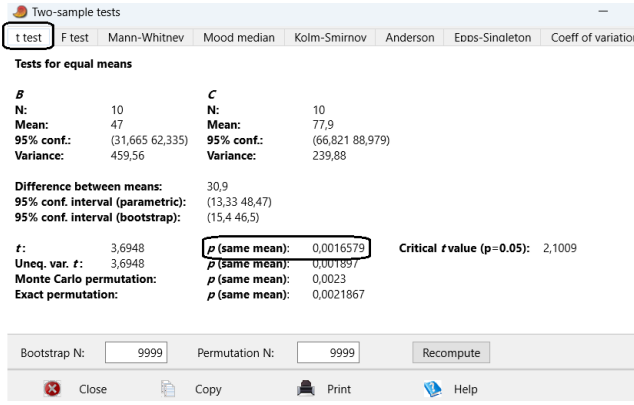


Figure 5. Calculated "p" value for the T-test

Conclusion of the T-test:

$\alpha = 0.05$, $p = 0.0016579$, Since $p < \alpha$, we reject the null hypothesis H_0. Based on the results of the T-test, we can confirm that there are significant paired differences, indicating an improvement in students' knowledge. For example, this could be related to the introduction of new teaching methods.

Use of Regression and Correlation Analysis in Pedagogical Research with the Support of the PAST Statistical

We will use the same example from the previous chapter and apply regression and correlation analysis with the support of the PAST software as can be seen in Fig. 6. Ten students took a pretest at the beginning of the semester on statistical terms, scoring 12, 25, 30, 38, 40, 52, 60, 65, 70, and 78 (with a maximum score of 100). After completing the semester, the same group took a posttest with scores of 50, 60, 70, 85, 70, 77, 90, 92, 85, and 100. Evaluate the effectiveness of their knowledge after the semester (Rudolf, 2021).

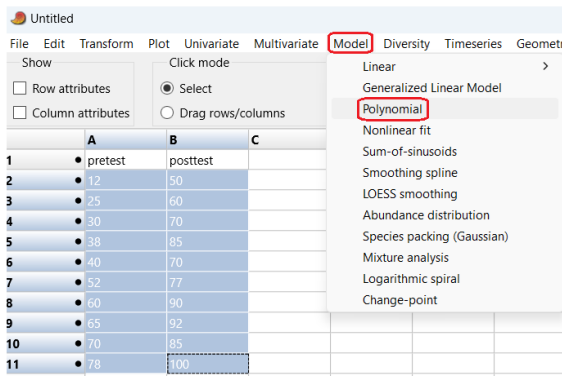


Figure 6. Loading pretest and posttest scores and selecting the function

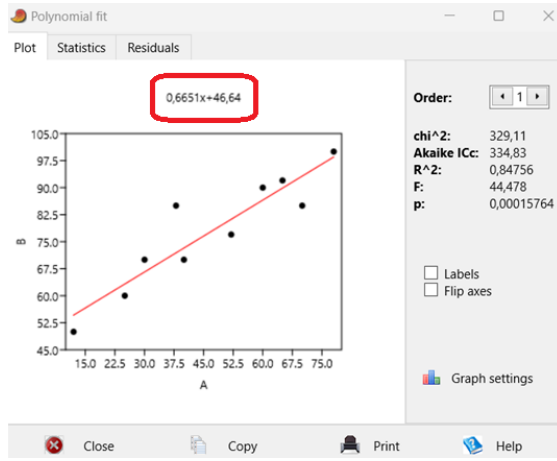


Figure 7. The displayed linear function of the regression analysis

Based on the representation of the linear regression function in the form of a first-degree polynomial, it can be observed that the points are distanced from the line (see Figure 7). This indicates an increase in students' knowledge and scores in the post-test compared to the pre-test. If the points were on the line, knowledge would remain unchanged, and the relationship would follow the function of the line not passing through the origin ($y = 0.6651x + 46.64$). However, the correlation coefficient result shows a high dependency between pre-test and post-test scores (see Figure 8), reflecting changes before and after the event (Andel, 2019).

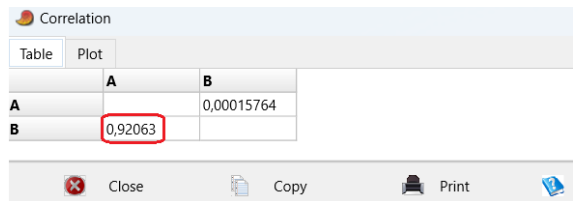


Figure 8. The correlation coefficient of the dependence between pretest and posttest scores

Analysis of results

The analysis of results using selected statistical methods such as ANOVA, t-test, and regression and correlation analysis in educational research provides key conclusions about the relationships between variables and the effectiveness of teaching methods. ANOVA is used to compare the means of multiple groups to determine if statistically significant differences exist. T-tests examine the differences between two groups, often applied in evaluating intervention programs. Regression and correlation analyses reveal relationships between independent and

dependent variables, offering valuable insights for educational decision-making. The findings underscore the importance of using statistical methods for drawing informed conclusions.

Conclusion

Statistical methods such as ANOVA, T-tests, regression, and correlation analysis play a critical role in educational research for analyzing and interpreting data within educational environments. ANOVA compares multiple groups, while the T-test focuses on differences between two groups. Regression and correlation analysis provide insight into relationships between variables. These methods are explained with examples from educational practice. Selected methods ensure objective and scientifically supported results, which can lead to improvements in educational strategies and interventions within pedagogical research.

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