Covariance Analysis for the Evaluation of English Teaching Effect

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Abstract. The knowledge basis of college students at the time of admission has a crucial impact on their future academic performance. Therefore, when evaluating the teaching effect of different groups of college students, the analysis of variance on the original data cannot ignore the influence of students’ English foundation before entering a university on their English learning in college. This paper uses the method of covariance analysis to make a comparison and evaluation of the English learning effect of four colleges, which can exclude the influence of students' entrance basis on the teaching effect.

Introduction

With the further development of the college education reform, improving teaching quality has become more and more important to the college. How to evaluate teachers' teaching quality scientifically, objectively and impartially and how to measure teachers' teaching quality through the improvement of students' academic performance has become an important content of teaching quality management [1].

ANOVA is to decompose the total variance into the components of each variance and use the method of significance test to determine the factors that may affect the results [2]. ANOVA can be classified into univariate analysis and multivariate analysis according to the number of influencing factors [3]. It can be used in teaching evaluation to analyze whether the factors affecting students’ performance are significant [4].

However, when comparing and evaluating the learning effect of the same course for students from different colleges or majors, it is difficult to obtain a fair evaluation of teachers’ teaching effect by using variance analysis on the original data of college students directly. Colleges with good academic performance will be considered as having good teaching effect, but colleges with poor academic performance may be because of the poor foundation of students [5]. This is because the analysis of variance ignores the influence of the subject foundation of students before enrollment on the teaching effect, the conclusion may not reflect the real teaching effect [6].

Covariance analysis continues the basic idea of ANOVA and takes the influence of covariables into account when analyzing the variation of observed variables [7]. After the influence of covariance is eliminated by regression analysis, ANOVA is used to analyze the influence of control variables on observation variables [8].

By applying covariance analysis to our teaching evaluation, we can eliminate the influence of students' basic knowledge on teaching effect, so as to obtain more convincing teaching quality evaluation.

Basic Theory of Covariance Analysis

Covariance analysis is a statistical analysis method combining regression analysis and variance analysis, which can be used to compare the difference of a variable (factor) at different levels.

The variables to be compared in an experiment are expressed in terms of y, and the covariables related to it are expressed in terms of x. In the experiment. A single factor is changing (it has r levels).
Under the ith level, n_i independent observations are made on the test indicators y and x. The records are shown in Table 1.

| level | variables | covariables |
|-------|-----------|-------------|
| 1     | y_{i1}, y_{i2}, \ldots y_{in} | x_{i1}, x_{i2}, \ldots x_{in} |
| 2     | y_{i1}, y_{i2}, \ldots y_{in} | x_{i1}, x_{i2}, \ldots x_{in} |
| \ldots | \ldots | \ldots |
| r     | y_{r1}, y_{r2}, \ldots y_{rn} | x_{r1}, x_{r2}, \ldots x_{rn} |

In order to calculate the corresponding statistics of covariance analysis from these test results and obtain the covariance statistical table, we first need to carry out the following calculation steps.

Step 1. Calculate the mean, the sum of squares and the sum of cosquares of the two variables.

\[
\bar{x}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} x_{ij},
I_{xxi} = \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_i)^2
\]

\[
\bar{y}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} y_{ij},
I_{yyi} = \sum_{j=1}^{n_i} (y_{ij} - \bar{y}_i)^2
\]

\[
I_{xyi} = \sum_{j=1}^{n_i} (x_{ij} - \bar{x}_i)(y_{ij} - \bar{y}_i)
\]

(1)

Step 2. Calculate the sum of squares and cosquares within the common group.

\[
I_{xxw} = \sum_{i=1}^{p} I_{xxi},
I_{yyw} = \sum_{i=1}^{p} I_{yyi},
I_{xyw} = \sum_{i=1}^{p} I_{xyi}
\]

(2)

Step 3. Calculate the total mean, total sum of squares and cosquares.

\[
n = \sum_{i=1}^{p} n_i
\]

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{p} \sum_{j=1}^{n_i} x_{ij},
I_{xxT} = \sum_{i=1}^{p} \sum_{j=1}^{n_i} (x_{ij} - \bar{x})^2
\]

\[
\bar{y} = \frac{1}{n} \sum_{i=1}^{p} \sum_{j=1}^{n_i} y_{ij},
I_{yyT} = \sum_{i=1}^{p} \sum_{j=1}^{n_i} (y_{ij} - \bar{y})^2
\]

\[
I_{xyT} = \sum_{i=1}^{p} \sum_{j=1}^{n_i} (x_{ij} - \bar{x})(y_{ij} - \bar{y})
\]

(3)

Then the covariance analysis table (Table 2) can be obtained from the calculation results above.
Table 2. Analysis of covariance table.

| Variance Source | Modified Squares | Sum of Squares | Modified Degree of Freedom | Square of Means | F Value | The Critical Value |
|-----------------|------------------|----------------|---------------------------|-----------------|---------|-------------------|
| Within Groups   | $Q_w = l_{syw} - (l_{xyw}^2) / l_{xxw}$ | $n-p-1$ | $V_w = \frac{Q_w}{n-p-1}$ | $F_w = \frac{V_w}{V_u}$ |
| Between Groups  | $Q_b = Q_T - Q_w$ | $p-1$ | $V_b = \frac{Q_b}{p-1}$ |
| Total           | $Q_T = l_{syT} - (l_{xyT}^2) / l_{xxT}$ | $n-2$ |

Considering the influence of covariables, the mean value of the results should be reordered to set the covariables at the same level.

$$\bar{y}_i = \bar{y}_i + b_w (\bar{x} - \bar{x}_i) = \bar{y}_i - b_w (\bar{x}_i - \bar{x}), \quad b_w = \frac{L_{syw}}{L_{xxw}}$$  \hspace{1cm} (4)

Ranking according to the modified mean, results will not be affected by the covariates, which will be more reliable than before.

Experiment

Data Source

There are original data of the English entrance examination scores and CET-4 scores of students from the four schools of USTB (school of chemical and biological engineering, school of advanced engineers, school of grammar and metallurgy and ecological engineering) in 2014. These data are used to test whether there is a significant difference in CET-4 scores among different schools. Results are taken as a reference to judge the English teaching situation received by students of different colleges after enrollment. The score of the English entrance examination is $x$, and the score of CET-4 is $y$. Part of the original data is shown as follows.

Table 3. Original data of CET-4 scores of students from four schools.

| College | school of chemical and biological engineering | school of advanced engineers | school of grammar | school of metallurgy and ecological engineering |
|---------|-----------------------------------------------|-------------------------------|------------------|-----------------------------------------------|
| 1       | 459                                           | 500                           | 534              | 555                                           |
| 2       | 458                                           | 481                           | 424              | 545                                           |
| 3       | 431                                           | 480                           | 489              | 393                                           |
| 4       | 430                                           | 477                           | 462              | 369                                           |
| ...     | ...                                           | ...                           | ...              | ...                                           |
| ni      | 407                                           | 460                           | 420              | 351                                           |
| Student Amount | 90                           | 126                           | 172              | 173                                           |
| Average | 495.63                                       | 505.64                        | 524.63           | 484.68                                        |

Table 4. Original data of entrance examination scores of students from four schools.

| College | school of chemical and biological engineering | school of advanced engineers | school of grammar | school of metallurgy and ecological engineering |
|---------|-----------------------------------------------|-------------------------------|------------------|-----------------------------------------------|
| 1       | 60                                            | 71                            | 66.5             | 75                                            |
| 2       | 66                                            | 72.5                          | 74               | 69.5                                          |
| 3       | 67                                            | 53.5                          | 65               | 64                                            |
| 4       | 71                                            | 60                            | 64               | 63                                            |
ANOVA of the Original Data

Calculate the arithmetic average scores of the four colleges. Then rank them according to the average scores.

Table 5. Ranking of CET-4 average score of four schools.

| College                | School of Grammar | School of Advanced Engineers | School of Chemical and Biological Engineering | School of Metallurgy and Ecological Engineering |
|------------------------|-------------------|------------------------------|-----------------------------------------------|-----------------------------------------------|
| Ranking                | 1                 | 2                            | 3                                             | 4                                             |
| Average                | 524.63            | 505.64                       | 495.63                                        | 484.68                                        |

The average scores of the four colleges are quite different. Students in School of Grammar scored nearly 40 points higher in English than those in the School of Metallurgy and Ecological Engineering. This is consistent with our common impression that liberal arts schools do better in English than engineering schools. Without considering the English entrance foundation of students from different schools, the original CET-4 scores of students are analyzed by single factor ANOVA. The result of single-factor ANOVA is shown as follows.

Table 6. Results of single-factor ANOVA table.

| Variance Source     | Sum of Squares       | Degree of Freedom | Square of Means | F Value      | Significant   |
|---------------------|----------------------|-------------------|-----------------|--------------|---------------|
| Between Schools     | 144182.4103          | 3                 | 48060.8034      | 13.97347173  | **            |
| Error               | 1915763.529          | 557               | 3439.43183      |              |               |
| Total               | 2059945.939          | 560               | 51500.24        |              |               |

From the single factor ANOVA table, there are significant differences in the English proficiency of the four colleges. However, the influence of entrance scores on CET-4 scores has not been considered. Entrance examination results largely reflect students' English foundation, which in turn has a great impact on their English performance after entering universities. Therefore, the influence of entrance scores on cet-4 scores cannot be ignored. In the next part, covariance analysis will be used to modify the model, so as to obtain a more fair evaluation of the teaching effect of each college.

Analysis of Covariance for Modification

According to the principle of covariance analysis, the results of it are obtained as follows.

Table 7. Results of analysis of covariance table.

| Variance Source     | Modified Sum of Squares | Modified Degree of Freedom | Square of Means | F Value | The Critical Value |
|---------------------|-------------------------|----------------------------|-----------------|---------|--------------------|
| Within Groups       | 945924.9                | 556                        | 1701.304        | 15.89237| 3.817              |
| Between Groups      | 81113.25                | 3                          | 27037.75        |         |                    |
| Total               | 1027038                 | 559                        |                 |         |                    |
After excluding the influence of entrance English scores, the differences in CET-4 scores of the four schools are more significant. This consequence further confirms that there are certain differences in the English teaching effect in the four schools.

After the covariance analysis table is obtained, the mean value of each school is adjusted by Equation (4). After students' entrance scores are classified into the same level, mean values of English scores are as follows.

Table 8. Ranking of modified CET-4 average score of four schools.

| College                  | School of Grammar | School of Chemical and Biological Engineering | School of Advanced Engineers | School of Metallurgy and Ecological Engineering |
|--------------------------|-------------------|-----------------------------------------------|-------------------------------|-----------------------------------------------|
| Ranking                  | 1                 | 2                                             | 3                            | 4                                             |
| Average                  | 518.8147          | 500.8975                                      | 499.614                       | 491.0031                                      |

Compared with the unmodified average scores of the four schools, the differences between the schools are significantly moderated. The difference of average English score of grammar school and the average English score of metallurgy and ecological engineering school is reduced to 30 points or so. The average score of the college of chemistry and biology even exceeds that of the college of advanced engineers. This shows that the English teaching effect of students in the college of chemistry and biology is better than that of the college of higher engineers after the influence of students’ entrance scores is removed, which is obviously different from the previous results analyzed by one-way ANOVA. Of course, this also reflects the importance of English foundation to English learning from another aspect. Students need to be reminded that if they want good grades in English, they must keep studying for a long time.

**Conclusion**

English foundations of students in different schools are obviously different. Generally speaking, liberal arts students have a better foundation of English, and the teaching effect of English subjects in liberal arts colleges is better. This conclusion is also proved by the English entrance scores and CET-4 scores of the university in this paper. Therefore, college administrators should pay more attention to the different English foundations of students in liberal arts and science colleges as well as paying attention to teaching students in accordance with their ability.

Teachers' teaching effect also has a certain impact on students' CET-4 scores. For example, in one of the schools in this paper, the college with less basic English entrance score has surpassed the college with a better foundation after a period of study. Therefore, college administrators can set up an incentive mechanism to mobilize the teaching enthusiasm of college teachers.

Of course, the analysis of this paper can also prove that the foundation of students does have a crucial impact on future English learning. This shows that students should not only strengthen their English foundation before college but also keep on English learning in colleges and universities.

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