Analysis of Multivariate Affective Instruction Evaluation on Engineering Instruction

Bao Rong Chang

Department of Electronic Engineering, Kao Yuan Institute of Technology

1821 Chung-Shan Rd., Lu -Chu Hsiang, Kaoshiung, Taiwan

Phone: (07) 6968121 # 1200, Fax: (07) 6977801, e-mail: brchang@cc.kyit.edu.tw

Abstract: The affective instruction evaluation includes five high-level layers on interaction relationship between people or from people to events and this is classified into five layers as follows: receiving, responding, valuing, organization, and characterization by value complex. However, the concrete information can not be quantized easily from this interaction relationship so as to take measure, form indexes, and make comparison in response to the external stimulation that is produced by the roles between the donor (teachers) and acceptor (students). The objective of this research is to seek the indexes of the multivariate affective instruction evaluation that is transformed by the grey relational analysis and the regression analysis based on 20 items (variables) of instruction opinion from sampling students. After classification through examples, the grey relational analysis is used to measure the strength of relation between variables; on the other hand, the regression analysis is applied to measure the statistic relation between variables. According to the degree of relation, we can explain what is the difference between teaching and learning on the affecti ve instruction domain for the same classroom students who take the various courses. According to the model of regression, we can show how is the difference between teaching and learning on the affective instruction domain for a single instructor who teaches the various lectures. These methods provide us the way to improve and promote the instruction activity on engineering education according to the results of the different indexes of the affective instruction evaluation. Therefore, the objectives of instruction can be achieved.

Keywords：Affective Instruction Evaluation, Grey Relational Analysis, Regression Analysis

1. Introduction

In general, the affective instruction evaluation is less applied than the cognitive instruction evaluation on the objectives of engineering instruction. However, the affective instruction evaluation includes five high-level layers [1] on interaction relationship between people or from people to events and this is classified into five high-level layers as follows: receiving, responding, valuing, organization, and characterization by value complex. Furthermore, the concrete information can not be quantized easily from this interaction relationship so as to take measure, form indexes, and make comparison in response to the external stimulation that is produced by the roles between the donor (teachers) and acceptor (students).

The objective of this research is to seek the indexes of the multivariate affective instruction evaluation that is transformed by the grey relational analysis and the regression analysis based on 20 items (variables) of instruction opinion from sampling students. Moreover, the difference between indexes on the affective instruction domain can show the different effect of teaching and learning during the semester. In fact, we first have to separate the type of applications on the grey relational analysis [2][3][4] and the regression analysis [5][6] before we employ these methods to evaluate the multivariate affective instruction. After classification through examples, the grey relational analysis is used to measure the strength of relation between variables; on the other hand, the regression analysis is applied to measure the statistic relation between variables. According to the degree of relation, we can explain what is the difference between teaching and learning on the affective instruction domain for the same classroom students who take the various courses. According to the model of regression, we can show how is the difference between teaching and learning on the affective instruction domain for a single instructor who teaches the various lectures.

In this study, we apply the grey relation analysis and the regression analysis to the affective instruction evaluation. These methods provide us the way to improve and promote the instruction activity on engineering education according to the results of the different indexes of the affective instruction evaluation. Therefore, the objectives of instruction can be achieved.

2. Grey Relational Analysis

The original sequence is assumed to be ether referred sequence $x_o(k)$ or comparative sequence $x_i(k)$, i=1,2.‥,m；k=1,2,‥,n.， if the sequences are comparable and convenient for data-computing in the grey relational analysis [2][3][4], the data must be processed as follows： $x_i^*(k) = \frac{x_i(k)}{a}$. There are several methods provided for computation below: (1)initialization： $a = x_i(1)$, (2)mean ： $a = \frac{1}{n}\sum_{k=1}^{n} x_i(k)$, (3)maximum value ： $a = \max\{x_i(k)\}$, (4)minimum value ： $a = \min\{x_i(k)\}$, (5)interval value ： $x_i^* = \frac{\max\{x_i(k)\} - x_i(k)}{\max\{x_i(k)\} - \min\{x_i(k)\}}$,and (6)proportional value ： $a = 10^m$. After that, we have to find the difference between the sequences such as $\Delta_{oi}(k) = | x_o^*(k) - x_i^*(k) |$. Additional, the maximum and minimum values of the difference are calculated, that is, $\Delta_{\max} = \max_i \max_k \Delta_{oi}(k)$ and $\Delta_{\min} = \min_i \min_k \Delta_{oi}(k)$. Therefore, we defined the grey relation coefficient

$$g_{oi}(k) = \frac{\Delta_{\min} + z\,\Delta_{\max}}{\Delta_{oi}(k) + z\,\Delta_{\max}}, \qquad (1)$$
$$0 < g_{oi}(k) \le 1$$

and the grey relation.

$$\Gamma_{oi} = \frac{1}{n}\sum_{k=1}^{n} g_{oi}(k) \qquad (2)$$

The relation means the measure of strength or degree of relationship between two factors. According to (1), the magnitude of $\Delta_{oi}(k)$ is the dominate of $g_{oi}(k)$ formula. Actually, the grey relational analysis is to measure the magnitude of absolute value of data deviation between sequences or to measure the degree of approximation for the distance of two geometric curves that is formed by the data from sequences.

2. Multivariate Regression Analysis

The multivariate regression analysis [5][6] is to study the statistic relation for the multiple linear models between a set of independent variables and a dependent variable. This model can be used to estimate or predict the future observation. In fact, the phenomenal in the real world can be constructed as a multivariate regression model so as to improve or promote the precise of output of the estimation or prediction. The multivariate regression model in general is defined in the following:

$$Y_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + \cdots\cdots + b_k X_{ki} + e_i \qquad (3)$$

and the sample multivariate regression equation as shown below:

$$\hat{Y}_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + \cdots\cdots + b_k X_{ki} \qquad (4)$$

the model regression equation is as follows:

$$E(Y) = b_0 + b_1 X_{1i} + b_2 X_{2i} + \cdots\cdots + b_k X_{ki} \qquad (5)$$

In order to solve the estimator $b_0, b_1, \cdots\cdots, b_k$, we employ the least square method to minimize the sum of square of the residual error expressed below:

$$Min. \quad q = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2 \qquad (6)$$

It typically turns out to be a normal equation [7] $A^T AX = A^T Y$ where A is a coefficient matrix for

$b_0, b_1, \cdots\cdots, b_k$. Therefore, the solution to X is equal to $A^{+}Y$ where A^{+} is a pseudo inverse [7] of A defined as $(A^T A)^{-1} A^T$.

3. Affective Instruction Evaluation

The affective instruction evaluation includes five high-level layers on interaction relationship between people or from people to events and this is classified into five high-level layers as follows: (I) receiving, (II) responding, (III) valuing, (IV) organization, and (V) characterization by value complex. On engineering education, we design the following lecture evaluation items or opinions that have two categories (á) self-review for students study, and (â) opinions for teacher’ s instruction.

(á) Self-review for students study:

1. Listening comprehension
2. After-class review
3. Problems Solving down by yourself
4. Intersecting on this course
5. Hours per course
6. Hours per week for studying this course
7. Attendances
8. Easy or Difficult for contents of this course
9. Course loading
10. Academic performance

(â) Opinions for teacher’ s instruction:

1. Contents of lecture
2. Way of teaching
3. Material–preparing for lecture
4. Ability of teacher’ s oral express
5. Program schedule
6. Solution to questions
7. Aid in studying
8. Way of instruction evaluation
9. Learning from lecture
10. Effect of this course

As mentioned above, each item could be graded 1 to 7 when students evaluate every question during the semester.

Furthermore, A map between the affective domain and the opinions of lecture evaluation was done as shown below.

Table 1

Contrast table between affective domain and two categories of instruction evaluation

Affective Domain	**(á) Self-review for students study**	**(â) Opinions for teacher' s instruction**
I	1	1,3,4
II	3,9	2,8
III	2,4	5,6
IV	5,6,8	7,4
V	7,10	10

Next, we obviously have to define the indexes of the multivariate affective instruction evaluation for the analysis of effect of instruction activity between teachers and students. We define a column vector X that represents the 10 average grades for each item of the self-review for students study in the multivariate affective instruction evaluation. Y is naturally defined as a column vector that represents the 10 average grades for each item of the opinions for teacher' s instruction. A is a coefficient matrix defined in the previous section; thus, the equation of $AX = Y$ states a multivariate regression model where X is transformed into Y. Therefore, a equation $BY = X$ is a multivariate regression model where Y is transformed into X. Based on $AX = Y$, the first index of the affective instruction evaluation, IA1, represents how is the difference between actual learning and predict learning situation as the same grades of category B on the affective instruction domain for a single instructor who teaches the various lectures.

$$IA1 = \sqrt{\frac{\left\| Y^{*} - AX^{*} \right\|^{2}}{N}} \qquad (7)$$

The second index of the affective instruction evaluation, IA2, represents how is the difference between actual learning and predicted learning situation for a single instructor who have the same weight average grade as the others on the category â instruction domain. The weight w for the category â instruction domain is calculated from the grey relation matrix.

$$w^{T} AX_{i} = w^{T} Y_{i}^{*} = \text{constant}$$

$$X_{i} = A^{+} Y_{i}^{*} = (A^{T} A)^{-1} A^{T} Y_{i}^{*}$$

$$IA2 = \sqrt{\frac{\left\| X^{*} - X \right\|^{2}}{N}} \tag{8}$$

where N is the number of item on the category á instruction domain.

According to $BY = X$, the third index of the affective instruction evaluation, IA3, represents what is the difference between teaching and learning on the affective instruction domain for the same classroom students who take the various courses.

$$IA3 = \sqrt{\frac{\left\| X^{*} - BY^{*} \right\|^{2}}{N}} \tag{9}$$

The fourth index of the affective instruction evaluation, IA4, represents what is the difference between actual teaching and predicted teaching situation for a single class that have the same weight average grade as the others on the category á instruction domain. The weight v for the category á instruction domain is calculated from the grey relation matrix.

$$v^{T} BY_{j} = v^{T} X_{j}^{*} = \text{constant}$$

$$Y_{j} = B^{+} X_{j}^{*} = (B^{T} B)^{-1} B^{T} X_{j}^{*}$$

$$IA4 = \sqrt{\frac{\left\| Y^{*} - Y \right\|^{2}}{N}} \tag{10}$$

where N is the number of item on the category â instruction domain.

4. Examples and results

This study adopted a period of 6 semesters that collected 1476 samples for each category á and category â instruction evaluation data on the engineering courses. Based on these data, the average grade of 1476 times for each item on category á and category â instruction domain can be done in form of 20 sequences, and each sequence contains 6 columns. After that, we apply the grey relational analysis to generate a grey relation matrix. The eigen vector of this matrix with respect to the maximum eigen value was found, and each entry of this vector stands for the weight of item for category á and category â instruction domain. The weight vector also is normalized so that the sum of entries in this weight vector is one.

$$w = [0.1016, 0.1022, 0.1009, 0.1020, 0.1005, 0.1007, 0.0993, 0.0960, 0.0976, 0.0991]$$

$$v = [0.0924, 0.0962, 0.1008, 0.1028, 0.0923, 0.0900, 0.1105, 0.1022, 0.1036, 0.1090]$$

Secondly, the coefficient matrix of $AX = Y$ and $BY = X$ as mentioned earlier was computed in the following:

$$A = \begin{bmatrix} 10.7810 & -0.3810 & 0.9370 & -0.6060 & -0.2070 & -0.9650 \\ 10.4060 & -0.5640 & 0.7540 & -0.6190 & -0.0702 & -0.6450 \\ 10.3310 & -0.1780 & 0.8410 & -0.5630 & -0.3670 & -0.8860 \\ 9.6860 & -0.4670 & 0.8350 & -0.5470 & -0.2720 & -0.5290 \\ 11.3110 & -0.3310 & 0.8410 & -0.7420 & -0.3980 & -0.7720 \\ 11.6750 & 0.0381 & 0.8760 & -0.6270 & -0.3830 & -1.3990 \\ 12.5830 & 0.0345 & 0.7060 & -0.5860 & -0.1820 & -1.6880 \\ 13.7890 & 0.0061 & 0.4700 & -0.6240 & -0.2020 & -1.7160 \\ 10.3230 & -0.1190 & 0.6670 & -0.4820 & -0.4760 & -0.8200 \\ 11.3150 & -0.1290 & 0.7640 & -0.5610 & -0.3710 & -1.1140 \end{bmatrix}$$

$$B = \begin{bmatrix} 10.7810 & -0.3810 & 0.9370 & -0.6060 & -0.2070 & -0.9650 \\ 10.4060 & -0.5640 & 0.7540 & -0.6190 & -0.0702 & -0.6450 \\ 10.3310 & -0.1780 & 0.8410 & -0.5630 & -0.3670 & -0.8860 \\ 9.6860 & -0.4670 & 0.8350 & -0.5470 & -0.2720 & -0.5290 \\ 11.3110 & -0.3310 & 0.8410 & -0.7420 & -0.3980 & -0.7720 \\ 11.6750 & 0.0381 & 0.8760 & -0.6270 & -0.3830 & -1.3990 \\ 12.5830 & 0.0345 & 0.7060 & -0.5860 & -0.1820 & -1.6880 \\ 13.7890 & 0.0061 & 0.4700 & -0.6240 & -0.2020 & -1.7160 \\ 10.3230 & -0.1190 & 0.6670 & -0.4820 & -0.4760 & -0.8200 \\ 11.3150 & -0.1290 & 0.7640 & -0.5610 & -0.3710 & -1.1140 \end{bmatrix}$$

Moreover, the pseudo inverse of A and B was calculated as follows:

$$A^{+} = \begin{bmatrix} -1.0759 & 0.7187 & 0.7658 & 0.0810 & -0.4487 & 0.0171 & 0.3832 & -0.2000 & 0.2681 & -0.3119 \\ -11.6822 & 6.7174 & 8.6620 & -0.9008 & -2.1896 & 2.8745 & 4.5570 & -3.4769 & 0.4577 & -4.2097 \\ -1.9744 & 1.7725 & 2.9218 & 0.2891 & -1.9822 & 1.3856 & 1.8226 & -2.4700 & -0.1626 & -0.9807 \\ -0.4887 & 0.7300 & 1.5192 & 2.0748 & -5.9879 & -1.5690 & 1.1953 & -0.7324 & 3.1487 & 0.9265 \\ -8.5849 & 7.0471 & 6.6566 & -0.2834 & -2.9013 & 1.6391 & 4.4219 & -2.6461 & -0.8214 & -3.8706 \\ -8.0152 & 5.1493 & 5.7666 & 0.0624 & -1.6942 & 0.9606 & 2.5078 & -2.1895 & 0.9992 & -2.7469 \end{bmatrix}$$

$$B^{+} = \begin{bmatrix} 0.0477 & 0.0259 & -0.1363 & 0.0553 & 0.1245 & -0.0022 & 0.0393 & 0.0131 & -0.0838 & 0.1431 \\ 0.1532 & 0.6100 & -1.1806 & 0.5254 & 0.8255 & 0.2893 & -0.0222 & 0.0477 & -0.9435 & 1.0575 \\ 0.3679 & 0.5934 & -1.2326 & 0.5719 & 0.7751 & 0.0861 & -0.0122 & -0.0471 & -1.0128 & 1.2299 \\ 0.4371 & 0.4499 & -1.2937 & 0.4928 & 0.8380 & 0.3921 & 0.3303 & -0.2047 & -1.1579 & 0.9160 \\ 0.4786 & 0.3471 & -1.4838 & 0.4796 & 0.9839 & 0.3256 & 0.4045 & -0.2071 & -1.2249 & 1.0292 \\ 0.3857 & 0.4902 & -1.1871 & 0.5308 & 0.8195 & 0.1477 & 0.1418 & -0.1191 & -1.0362 & 1.0824 \end{bmatrix}$$

Finally, we explain how to work four indexes of the multivariate affective instruction evaluation by 10 cases.

Table 2

The weighting average grade on á and â categories for 10 cases

Weighting average grade	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**	**Case 10**
á category	4.7	4.7	5.0	4.1	4.4	5.4	4.7	5.0	4.1	4.4
â category	4.7	4.7	6.1	4.1	4.1	5.2	5.2	5.2	3.5	4.7

Table 3

Four indexes of multivariate affective instruction evaluation for 10 cases

Indexes	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**	**Case 10**
IA1	0.5399	0.5709	0.9753	0.8087	0.4954	0.3374	0.4999	0.6316	1.0486	0.2495
IA2	0.5757	0.6448	0.5616	0.3620	0.4100	0.6821	0.7405	0.9992	0.7249	0.4035
IA3	0.5446	0.4548	0.9424	0.7475	0.6971	0.7560	0.6698	0.6490	0.8543	0.5688
IA4	0.5219	0.5043	0.4644	0.6950	0.1606	0.3839	0.4466	0.4537	0.9493	0.3256

5. Discussions and Conclusion

From Table 3, the teacher on case 10 with the lowest value of IA1 have the best teaching performance on his lecture activity because the affective error i.e. the magnitude of IA1 is the lowest between cases. Similarly, the class on case 2 with the lowest value of IA3 has the best learning comprehension for all students in this class. On the other hand, cases 1,2,and 10 have the same the grade on category â, but the teacher on case 10 have the better teaching effect on students than the others. Similarly, cases 4 and 9 have the same the grade on category á, but students in the class on case 4 have better learning interaction with teacher than case 9 did.

After the above discussions, we can conclude that this study provides us the way to improve and promote the instruction activity on engineering education according to the results of the different indexes of the affective instruction evaluation. Therefore, the objectives of instruction can be achieved.

References:

1. A manual for Teachers Instruction Evaluation in the Junior College, Technological & Vocational Education Department, Ministry of Education Press, Taiwan, 1989.
2. J. L. Deng, " Introduction to Grey System Theory", the Journal of Grey System, vol. 1, no. 1, pp. 1-24, 1989.
3. J. L. Deng, A Course on Grey System Theory, Huazhong University of Science & Technology Press, Wuhan, 1990.
4. J. L. Deng, The Essential Methods of Grey Systems, Huazhong University of Science & Technology Press, Wuhan, 1992.
5. J. Neter, M. H. Kutner, C. J. Nachtsheim, and W. Wasserman, Applied Linear Regression Methods, 3rd edition, Irwin, Illinois, 1996.
6. R. A. Johnson, Miller & Freund' s Probability & Statistics for Engineers, 5th edition, Prentice Hall, New Jersey, 1994.
7. R. E. Larson, and B. H. Edwards, Elementary Linear Algebra, 3rd edition, Heath, Lexington, M.A., 1996.