

ITEMS SELECTION FOR AFFECTIVE INSTRUCTION EVALUATION AND CHOSEN ITEMS' WEIGHTING DETERMINATION ON ENGINEERING INSTRUCTION

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Abstract $\frac{3}{4}$ The traditional affective instruction evaluation on engineering education has contained two separate sections, (I) Section I: Student self-evaluation (include 10 items) and (II) Section II: Evaluation of the instructor's teaching (include 10 items). These 20 items were usually determined by some of the experts or researchers on the affective instructional domain. However, some of items within two sections introduced above could be out of date as time goes by. In another words, some of items might be eliminated, or some of items would become more significant impact due to its availability on affective instruction evaluation. The significant items in evaluation list first were selected by utilized grey statistics technique so that the significant items could be retained and the redundant items were eliminated. Secondly, an optimal grey relational grade, combined by the grey approximation grade and the grey similarity grade, was applied to measure the non-linear relation for items within evaluation list such that the non-linear relation for items was achieved to determine the weight of each left item on evaluation. These methods provide us not only in qualitative but also in quantitative analysis to improve and promote the instruction activity on engineering education for accomplishing the objective of instructions.

Index Terms $\frac{3}{4}$ *Affective instruction evaluation, grey statistics technique, optimal grey relational grade.*

1. INTRODUCTION

In general, the cognitive instruction evaluation is traditionally used to measure the grade of instruction's examination at college. However, the instructional interaction between instructor and students cannot be shown in this cognitive instruction evaluation. This instructional interactive could executively reflect in the domain of affective instruction evaluation [1][2]. The traditional affective instruction evaluation on engineering education has contained some certain items for Section I: student self-evaluation as well as Section II: evaluation of the instructor's teaching. These items were usually determined by some of the experts or researchers on the affective instructional domain [3]. However, some of items within two separate sections could be out of date as time goes by. In another words, some of items might be eliminated, or some of items would become more significant impact due to its

availability on affective instruction evaluation. Therefore, two major problems occurred, and they have to be resolved in an appropriate manner. According to an example verified in this paper sampling the investigated 1200 samples' data of affective instruction evaluation [4], this paper thus proposed a fast method for filtering the redundant items within evaluation; furthermore, another technique also presented in this paper to calculate the weights of the left items for evaluation. The significant items in evaluation list first were selected depending on the appraisal coefficients by utilized grey statistics technique through means of grey whiten function so that the significant items could be retained and the redundant items were eliminated. Secondly, an optimal grey relational grade, combined by the grey approximation grade and the grey similarity grade, was applied to measure the non-linear relation for items within evaluation list such that the non-linear relation for items was achieved to determine the weight of each left item on evaluation. These methods provide us not only in qualitative but also in quantitative analysis to improve and promote the instruction activity on engineering education for accomplishing the objective of instructions.

2. APPROXIMATION, SIMILARITY, AND OPTIMAL RELATIONAL GRADE MEASUREMENTS

The quantitative relational grade for sequences as mentioned above can be extended into two aspects: (i) an approximation measure, and (ii) a similarity measure for the specific sequences based on the shapes of geometric curves of sequences that originally are to be time sequences or index sequences [5]. An approximation measurement is used to differentiate how close they are between sequences as shown in FIGURE 1. On the other hand, a similarity measurement as shown in FIGURE 1 is applied to discriminate how similar they are between sequences. Supposing a reference sequence and other comparative sequences are represented as x_{oj} and x_{ij} , $i=1,2,\dots,m$ and $j=1,2,\dots,n$. A data pre-process [5,6,7] was applied for transferring the original sequences to be a set of comparable sequences denoted by \tilde{x}_{oj} and \tilde{x}_{ij} , $i=1,2,\dots,m$ and $j=1,2,\dots,n$. An approximation measure between sequences, based on the shapes of geometric curves of \tilde{x}_{ij} sequences, is found by

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applying the quantitative grade on Equation (1), and denoted by A_{oi} .

$$A_{oi} = e^{-\frac{\bar{\Delta}_{oi}}{\Delta}}, \quad i=1,2,\dots,m \quad (1)$$

$$0 < A_{oi} \leq 1$$

where

$$\Delta_{oi}(j) = \|\tilde{\mathbf{x}}_{oj} - \tilde{\mathbf{x}}_{ij}\|_2, \quad (2)$$

$$\bar{\Delta}_{oi} = \sum_{j=1}^n \mathbf{a}_j \Delta_{oi}(j), \quad \sum_{j=1}^n \mathbf{a}_j = 1, \quad (3)$$

and

$$\bar{\Delta} = \sum_{i=1}^m \mathbf{w}_i \bar{\Delta}_{oi}, \quad \sum_{i=1}^m \mathbf{w}_i = 1. \quad (4)$$

Taking difference for consecutive adjacent vectors within a sequence generates a new sequence called the variation sequence represented by $\tilde{\mathbf{a}}_{ij} = \tilde{\mathbf{x}}_{ij+1} - \tilde{\mathbf{x}}_{ij}$, $j = 1, 2, \dots, n-1$. This process is referred to as the similarity generating [5]. A similarity measure between sequences, based on the shapes of geometric curves of $\tilde{\mathbf{a}}_{ij}$ sequences, is achieved by utilizing the quantitative grade on Equation (5), and denoted by S_{oi} .

$$S_{oi} = e^{-\frac{\bar{\Delta}_{oi}}{\Delta}}, \quad i=1,2,\dots,m \quad (5)$$

$$0 < S_{oi} \leq 1$$

where

$$\Delta_{oi}(j) = \|\tilde{\mathbf{a}}_{oj} - \tilde{\mathbf{a}}_{ij}\|_2, \quad (6)$$

$$\bar{\Delta}_{oi} = \sum_{j=1}^{n-1} \mathbf{b}_j \Delta_{oi}(j), \quad \sum_{j=1}^{n-1} \mathbf{b}_j = 1, \quad (7)$$

and

$$\bar{\Delta} = \sum_{i=1}^m \mathbf{w}_i \bar{\Delta}_{oi}, \quad \sum_{i=1}^m \mathbf{w}_i = 1. \quad (8)$$

The procedure just mentioned above demonstrates a generalized method for evaluating the relational grade among sequences on (i) an approximation measure, and (ii) a similarity measure for specific sequences based on the shapes of geometric curves of sequences in the multidimensional space as shown in FIGURE 1.

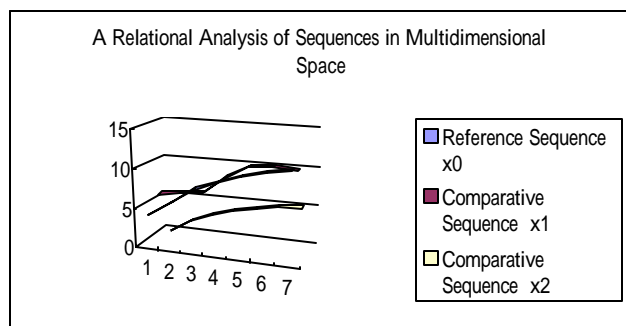


FIGURE 1.

The Comparisons of similarity and approximation have been made based on geometric curves for sequences with comparability to each other. The pair of (x_0, x_2) is great than (x_0, x_1) in similarity, but the pair of (x_0, x_1) is larger than (x_0, x_2) in approximation.

A linear combination of approximation grade with similarity grade could be made as to measuring the non-linear relation for sequences, and this measure can be referred to as an optimal relational grade, that is, a new single independent measure to analyse the relation among sequences in the multidimensional space.

$$\Gamma_{0i} = \mathbf{a}A_{oi} + \mathbf{b}S_{oi} \quad (9)$$

However, the undetermined coefficients in this linear combination form can't be determined in any simple mathematical method since this is an ill-posed problem [8,9] for being given the original finite but incomplete discrete data in those sequences \mathbf{x}_{oj} and \mathbf{x}_{ij} , where $i=1,2,\dots,m$ and $j=1,2,\dots,n$. That is, the given original finite discrete data in those sequences form an incomplete information system; thus, this is the uncertainty problem [8][9][10]. The Maximum Entropy Method [10][11][12][13] was frequently utilized for resolving the ill-posed problem in the literature. This method thus is applied herein to determine the coefficients in the linear combination form on Equation (9). The coefficients \mathbf{a} and \mathbf{b} are restricted in the following conditions, $0 \leq \mathbf{a} \leq 1$ and $0 \leq \mathbf{b} \leq 1$. Having Applied Maximum Entropy Method, the coefficient \mathbf{a} is determined by below [5].

$$\mathbf{a} = \frac{S_{0i}}{A_{0i} + S_{0i}}. \quad (10)$$

And then its optimal solution can be achieved as follows:

$$\Gamma_{0i} = \frac{2A_{0i}S_{0i}}{A_{0i} + S_{0i}} \quad (11)$$

3. CLUSTERING SEQUENCE TO CERTAIN GREY NUMBER BY APPLYING GREY STATISTICS

The grey statistics method, based on the grey whiten function generating, applied for clustering data within the sequences to a certain attribute that is described by a certain grey number [14][15]. This method can be interpreted to classify a certain attribute for the statistic index; basically, this is the process to transfer a white number to a grey number for classifying the attribute as follows.

Assuming the following indexes:
 $k=1,2,3,\dots,p$ (Index for the Grey Numbers)
 $j=1^\#, 2^\#, 3^\#, \dots, m^\#$ (Statistic Indexes)
 $i=I, II, III, \dots, l$ (Statistic Subjects)

Step1: Making a matrix below:

$$D = \begin{matrix} & \begin{matrix} 1^\# & 2^\# & \dots & m^\# \end{matrix} \\ \begin{matrix} I \\ II \\ \vdots \\ l \end{matrix} & \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1m} \\ d_{21} & d_{22} & \dots & d_{2m} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ d_{l1} & d_{l2} & \dots & d_{lm} \end{bmatrix} \end{matrix}$$

Step2: Giving the grey whiten functions, and taking an example as shown below.

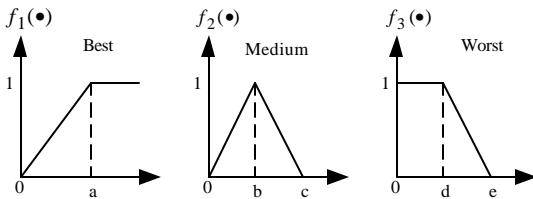


FIGURE 2.

An example for three grey numbers, “Best”, “Medium”, and “Worst”, as shown above

Step3: Finding appraisal coefficients

$$n_{jk} = \sum_{i=1}^l f_k(d_{ij}) \cdot N_i \tag{12}$$

where N_i stands for the number of persons in i th statistic subject who join this appraisal to evaluate the j th statistic index.

Step4: Decision-Making for classifying the attribute to the statistic index according to appraisal coefficients.

4. VERIFICATION AND DISCUSSION

The adopted currently available questionnaire for evaluating the affective instruction at most institutes has contained some certain items for Section I: student self-evaluation as well as Section II: evaluation of the instructor’s teaching utilized for examining a list in a single sheet providing for students to evaluate it conveniently [4]. There is an example sampled from a certain institute in Taiwan concerning the affective instruction for Section I: student self-evaluation as well as Section II: evaluation of the instructor’s teaching, totally containing 20 items as shown below.

		(a)
No.	Abbrev.	
1	x ₁	
2	x ₂	
3	x ₃	
4	x ₄	
5	x ₅	
6	x ₆	
7	x ₇	
8	x ₈	
9	x ₉	
10	x ₁₀	
		(b) Section
No.	Abbrev.	
1	y ₁	
2	y ₂	
3	y ₃	
4	y ₄	
5	y ₅	
6	y ₆	thinking and answer tough questions
7	y ₇	Instructor’s enthusiasm to counsel students’ academic task after class
8	y ₈	Instructor’s evaluation methods
9	y ₉	Degrees of getting benefit from learning this subject
10	y ₁₀	Instructor’s general teaching effect

The evaluation in this questionnaire contains 20 items (variables) and every item can be graded from 1 to 7 by integer. Every student completed his individual evaluation with respect to a lecture in a classroom, and then every individual evaluation done by students in this classroom was brought to a procedure that is a cumulative statistic process. This process turned out to be a list in one sheet in which the average value of each item for each section was obtained. Every evaluated list represented the result of affective instruction evaluation in a lecture (sample). This experimental work was operated in 1200 samples (lectures) for 6 semesters [4] to get the average value for each item per semester as listed in TABLE 2.

TABLE 2

(a) The evaluated grades for student self-evaluation in average from item x_1 to item x_{10} for 6 semesters

Abbrev. for items	Semester #1	Semester #2	Semester #3	Semester #4	Semester #5	Semester #6	Average for 6 semesters
x_1	5.01	4.83	4.42	4.39	4.49	4.92	4.68
x_2	3.72	3.52	3.10	3.29	3.38	3.34	3.39
x_3	4.94	4.52	4.25	3.90	4.42	4.06	4.35
x_4	4.79	4.54	4.28	4.21	4.44	4.30	4.43
x_5	4.22	4.03	4.21	3.81	4.25	3.74	4.04
x_6	4.16	3.95	3.53	3.63	3.94	4.11	3.89
x_7	6.71	6.36	6.15	5.78	6.30	6.53	6.31
x_8	4.64	4.81	4.37	4.22	4.70	4.81	4.59
x_9	4.52	4.67	4.19	3.91	4.47	4.66	4.40
x_{10}	4.27	4.39	4.10	4.07	4.19	4.29	4.22

(b) The evaluated grades for evaluation of the instructor’s teaching in average from item y_1 to item y_{10} for 6 semesters

Abbrev. for items	Semester #1	Semester #2	Semester #3	Semester #4	Semester #5	Semester #6	Average for 6 semesters
y_1	4.83	4.75	4.77	4.88	4.81	4.78	4.86
y_2	4.73	4.73	4.75	4.83	4.81	4.77	4.83
y_3	4.88	4.82	4.85	4.93	4.82	4.84	4.91
y_4	4.76	4.77	4.78	4.92	4.80	4.74	4.84
y_5	4.70	4.72	4.76	4.84	4.71	4.76	4.81
y_6	4.91	4.76	4.83	4.95	4.77	4.86	4.90
y_7	4.94	4.74	4.89	4.94	4.84	4.92	4.94
y_8	4.77	4.63	4.90	4.90	4.77	4.86	4.87
y_9	4.69	4.67	4.79	4.81	4.68	4.86	4.77
y_{10}	4.84	4.76	4.87	4.91	4.80	4.82	4.89

For this example cited in this paper, three grey numbers indicated as “Best Fitting”, “Fitting”, and “Worst Fitting” are represented as three grey whiten functions for appraisal displayed in the following FIGURE 3.

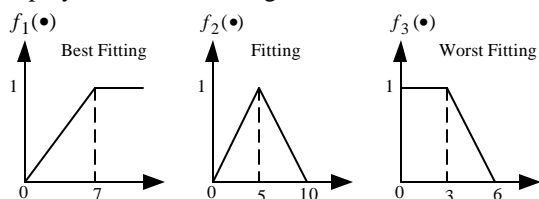


FIGURE 3.

Three grey whiten functions for three grey numbers, “Best Fitting”, “Fitting”, and “Worst Fitting”, respectively, are shown above as the appraisal functions.

After computation through the grey statistics method, a appraisal list with the appraisal coefficients for two separate sections for 6 semesters was asserted. According to the appraisal coefficients listed in TABLE 3, some of discussion could be made as follows:

Four appraisal coefficients, indicated as n_{23} , n_{53} , n_{63} , and n_{103} in TABLE 3- (a) as well as n_{33} , n_{43} , n_{53} , and n_{93} in TABLE 3- (b), could be viewed as the redundant items

because their values of the appraisal coefficient for grey number “Worst Fitting” were great than 3.5 in TABLE 3-(a) as well as 2.4 in TABLE 3- (b) if these two separate values 3.5 and 2.4 are set by an appropriate manner (rule) that the number of trimmed items can not exceed over half of the number of the original items for each section as mentioned in the precede paragraph. Therefore, the restriction was defined to view the values of appraisal coefficients 3.5 in TABLE 3-(a) as well as 2.4 in TABLE 3- (b) as a threshold so that the items with the values of appraisal coefficients higher than a threshold could consider these correspond items to be a redundant item.

The group of grey number “Fitting” has the highest values in their appraisal coefficient among three group (“Best Fitting”, “Fitting”, and “Worst Fitting”); therefore, a conclusion was stated that the items for Section I: student self-evaluation as well as Section II: evaluation of the instructor’s teaching were classified to the level of “Fitting” category.

Three appraisal coefficients, denoted by n_{11} and n_{71} in TABLE 3-(a) as well as n_{71} , n_{31} , n_{61} , and n_{71} in TABLE 3- (b), might be considered as the more significant items due to the higher values in the appraisal coefficient of grey number “Best Fitting” if a condition was set that the value of appraisal coefficient in grey number “Best Fitting” bigger than 4.0 in TABLE 3-(a) as well as 4.15 in TABLE 3-(b) as a level for classifying these items to be the significant ones. Two separate threshold values 4.0 and 4.15 are set in a manner to be similar to discussion #1 so that the number of significant items have to less than half of the number of the original items for each section as mentioned in the precede paragraph.

TABLE 3

A grey statistics applied for (a) Section I: student self-evaluation and (b) Section II: evaluation of the instructor’s teaching for 6 semesters to discover the redundant items by checking appraisal coefficients created from 3 grey whiten functions.

(a) Appraisal coefficients for Section I: student self-evaluation.

Appraisal Coefficient	$\sum_i f_1(\bullet) \cdot N_i$	Appraisal Coefficient	$\sum_i f_2(\bullet) \cdot N_i$	Appraisal Coefficient	$\sum_i f_3(\bullet) \cdot N_i$
n_{11}	4.008	n_{12}	5.608	n_{13}	2.647
n_{21}	2.907	n_{22}	4.070	n_{33}	5.217
n_{31}	3.662	n_{32}	5.218	n_{33}	3.303
n_{41}	3.705	n_{42}	5.312	n_{43}	3.147
n_{51}	3.953	n_{52}	4.852	n_{53}	3.913
n_{61}	3.331	n_{62}	4.664	n_{63}	4.226
n_{71}	5.406	n_{72}	4.434	n_{73}	0.073
n_{81}	3.953	n_{82}	5.510	n_{83}	2.816
n_{91}	3.776	n_{92}	5.284	n_{93}	3.193
n_{101}	3.616	n_{102}	5.062	n_{103}	3.503

(b) Appraisal coefficients for Section II: evaluation of the instructor's teaching.

Appraisal Coefficient	$\sum_i f_{1(\bullet)} \cdot N_i$	Appraisal Coefficient	$\sum_i f_{2(\bullet)} \cdot N_i$	Appraisal Coefficient	$\sum_i f_{3(\bullet)} \cdot N_i$
n ₁₁	4.117	n ₁₂	5.764	n ₁₃	2.394
n ₂₁	4.089	n ₂₂	5.724	n ₃₃	2.460
n ₃₁	4.163	n ₃₂	5.828	n ₃₃	2.286
n ₄₁	4.110	n ₄₂	5.754	n ₄₃	2.410
n ₅₁	4.069	n ₅₂	5.698	n ₅₃	2.503
n ₆₁	4.153	n ₆₂	5.820	n ₆₃	2.306
n ₇₁	4.182	n ₇₂	5.854	n ₇₃	2.243
n ₈₁	4.117	n ₈₂	5.766	n ₈₃	2.391
n ₉₁	4.071	n ₉₂	5.700	n ₉₃	2.500
n ₁₀₁	4.143	n ₁₀₂	5.800	n ₁₀₃	2.333

Regard to the weights of items for two separate sections, applying the relational analysis for sequences could resolve the weights determination by the following measures, the approximation grade, the similarity grade, and the optimal relational grade. After the evaluation of these grades mentioned above, the weights of items could be made in the following expression.

$$\mathbf{w} = \frac{\Gamma_{oi}}{\sum_{j=1}^m \Gamma_{oj}} \quad (13)$$

TABLE 4

The weights (\mathbf{w}_i) for (a) Section I: student self-evaluation and (b) Section II: evaluation of the instructor's teaching for 6 semesters before eliminating the redundant items. The symbols A_{oi} , S_{oi} , and Γ_{oi} represented the approximation grade, similarity grade, and optimal relational grade, respectively.

(a) Weights of items from item x_1 to item x_{10} for Section I: student self-evaluation.

No.	Abbrev. for 10 items	A_{oi}	S_{oi}	Γ_{oi}	\mathbf{w}_i
1	x_1	0.415	0.420	0.417	0.118
2	x_2	0.257	0.495	0.338	0.096
3	x_3	0.366	0.235	0.286	0.081
4	x_4	0.376	0.488	0.425	0.121
5	x_5	0.326	0.273	0.297	0.085
6	x_6	0.307	0.401	0.348	0.099
7	x_7	0.768	0.281	0.411	0.117
8	x_8	0.401	0.361	0.296	0.084
9	x_9	0.374	0.286	0.324	0.092
10	x_{10}	0.271	0.608	0.375	0.107

(b) Weights of items from item y_1 to item y_{10} for Section II: evaluation of the instructor's teaching.

No.	Abbrev. for 10 items	A_{oi}	S_{oi}	Γ_{oi}	\mathbf{w}_i
1	y_1	0.367	0.442	0.401	0.109
2	y_2	0.361	0.656	0.466	0.127
3	y_3	0.377	0.591	0.460	0.125
4	y_4	0.366	0.409	0.386	0.105
5	y_5	0.358	0.431	0.391	0.107
6	y_6	0.375	0.201	0.262	0.071
7	y_7	0.380	0.217	0.276	0.075
8	y_8	0.368	0.191	0.251	0.068
9	y_9	0.354	0.466	0.402	0.109
10	y_{10}	0.372	0.388	0.380	0.104

TABLE 5

The weights (\mathbf{w}_i) for (a) Section I: student self-evaluation as well as (b) Section II: evaluation of the instructor's teaching for 6 semesters after eliminating the redundant items. The symbols A_{oi} , S_{oi} , and Γ_{oi} represented the approximation grade, similarity grade, and optimal relational grade, respectively; moreover, the mark \times represented the deleted item.

(a) Weights of items for Section I: student self-evaluation.

No.	Abbrev. for 10 items	A_{oi}	S_{oi}	Γ_{oi}	\mathbf{w}_i
1	x_1	0.349	0.452	0.394	0.181
2	x_2	\times	\times	\times	\times
3	x_3	0.301	0.266	0.282	0.129
4	x_4	0.311	0.519	0.389	0.178
5	x_5	\times	\times	\times	\times
6	x_6	\times	\times	\times	\times
7	x_7	0.730	0.314	0.439	0.201
8	x_8	0.336	0.394	0.363	0.167
9	x_9	0.309	0.318	0.313	0.144
10	x_{10}	\times	\times	\times	\times

(b) Weights of items for Section II: evaluation of the instructor's teaching.

No.	Abbrev. for 10 items	A_{oi}	S_{oi}	Γ_{oi}	w_i
1	y_1	0.362	0.502	0.421	0.190
2	y_2	×	×	×	×
3	y_3	0.371	0.641	0.470	0.213
4	y_4	×	×	×	×
5	y_5	×	×	×	×
6	y_6	0.370	0.258	0.304	0.137
7	y_7	0.375	0.276	0.318	0.144
8	y_8	0.362	0.247	0.294	0.133
9	y_9	×	×	×	×
10	y_{10}	0.367	0.449	0.404	0.183

The results, before and after eliminating the redundant items, for evaluating the weights of items for two separate sections were listed in the TABLE 4 and 6, respectively. Four items were eliminated, and an important concept also was explained that (i) x_2 was merged to x_3 , x_5 was merged to x_7 , x_6 was merged to x_7 , and x_{10} was merged to x_9 , as shown in TABLE 5-(a) and (ii) y_2 was merged to y_1 , y_4 was merged to y_6 , y_5 was merged to y_7 , and y_9 was merged to y_{10} as shown in TABLE 5(b). Therefore, the original 10 items were reduced to a concise set with 6 items. The left items were x_1 , x_3 , x_6 , x_7 , x_8 , and x_{10} for further examining their weights among 6 items.

5. CONCLUSIONS

The main purpose of this study is for acquiring effective items and determining their weights for affective instruction evaluation on engineering education, and this study has the following properties:

- (1) The introduced method in this study can extract the redundant items for (a) Section I: student self-evaluation as well as (b) Section II: evaluation of the instructor's teaching by utilized the grey statistics method.
- (2) Applying the approximation grade, the similarity grade, and the optimal relational grade, the relational analysis could be used to determine the weights of items for affective instruction evaluation on engineering education
- (3) After eliminating the redundant items and determining the weights of items for two separate sections, the affective instruction evaluation becomes a concise set for items with highly efficiency and reliability.

This is show that the grey statistics method followed by the relational analysis can reach a set of items with various weights rather than identical weights and the number of items reduced to retain the significant ones with higher availability for evaluation of instructor's teaching in the affective instruction evaluation. This study just proposed one of methods for acquiring effective items and determining their weights for affective instruction evaluation on engineering education, but there are probably some other technique for resolving the same problem occurred in this paper.

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