EVALUATION OF FACULTY PERFORMANCE IN HIGHER EDUCATION USING AHP AND TOPSIS METHOD

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Abstract

Operations research is the development of approaches for optimal decision making. A prominent class of such problems is multi-criteria decision making (MCDM). Evaluation of faculty performance is a multi-criteria decision making (MCDM) problem. Best faculty members are the assets of an educational institution for increasing the quality education. So the performance evaluation of teachers is very much essential in education to enrich their knowledge and to assess each individual's contribution to the institution.

In this paper a study has been made by applying Analytic Hierarchy Process (AHP) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) to calculate the relative weights of factors to discover the importance of each factor to evaluate faculty performance in higher education. Here ten students feedback of a particular department have been considered to evaluate four teachers performances based on the criteria: subject knowledge, method of teaching, communication skill, accessibility, discipline & behavior, power of explanation and attitude. The proposed model yields the ranking of the four faculty members for evaluating their performances.

Keywords Multi-Criteria Decision Making (MCDM), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method, Analytical Hierarchy Process (AHP).

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I. INTRODUCTION

Higher education plays an important role in the cultivation of high-quality talents and the innovation of

Scientific and technological for a country.

Education system especially higher education contributes a major role to develop the nation. In an academic institution Teachers and Students are two main pillars and without these two an academic institution can never be survived. Teachers are the important assets of an educational institute and good teachers provide the good quality education among the students. It means that teachers' performance evaluation has become one of the important activities for the long run of an institution and for the development of the society.

In this paper, performance evaluation of faculty members for an educational institution is presented. The approach is based on AHP and TOPSIS methodology for selecting the best teaching associate. Several students gave their feedback for teachers depending upon different criteria.

Symbol descriptions

(1) aij Saaty relative importance scale, see Table 1

(2) λmax The largest eigen value of the matrix

(3) CI consistency index

(4) RI Saaty random index, see Table 2

(5) CR consistency ratio

(6)W Weight

II. CONCEPT OF AHP

A. Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) method is a combination of qualitative and quantitative analysis of multi-criteria and multi-objects decision evaluation approach. It is developed by T.L.Saaty[1], the famous professor of University of Pittsburgh during 1970s. This approach decomposes the decision problem to goals, criteria, decisions and other factors in the qualitative view, calculates the quantitative hierarchy importance weight by the internal relationship of these factors organizational structure, to assess the relative importance of various factors, and then quantify the decision processes of the complex structure question, so as to make the multi-objects and multi-criteria decision problems become easy and feasible. As an efficient tool in social and economic system decision analysis field, it is widely adopted to decision problem under uncertain situation in the field of such as education, economic, environmental engineering, energy arrangements etc.

Some of its applications include Layout Design[23],technology choice[7], in the evaluation of technology investment decisions, vendor selection of a telecommunications system[6], project selection, budget allocation,. The steps for implementing the AHP process are as follows:

- Define the Objectives.
- Identify the Criteria and Attributes.
- Select the Alternatives.
- Establishment of Hierarchical structure
- Design Questionnaire and survey
- Establish the Pair wise Comparison judgment matrices using Satty's 9-point scale.

TABLE. 1: The Comparative Scale in AHP from L.SAATY

Scale a_{ij}	**Definition**
1	**Equal importance of i and j**
3	**Weakly Important of i over j**
5	**Strong importance of i over j**
7	**Very Strong Importance of i over j**
9	**Extremely Importance of i over j**
2,4,6,8	**Intermediate values between two adjacent value**

- . Calculate Consistency (C.I) Index.

TABLE. 2: Random Index (R.I.) (SAATY, 1980)

MATRIX ORDER	**1,2**	**3**	**4**	**5**	**6**	**7**
R.I.	**0**	**0.52**	**0.89**	**1.12**	**1.26**	**1.36**

MATRIX ORDER	8	9	10	11	12	13
R.I.	1.41	1.46	1.49	1.52	1.54	1.56

- Comparison between Criteria and Alternatives
- Calculation of Final Rankings

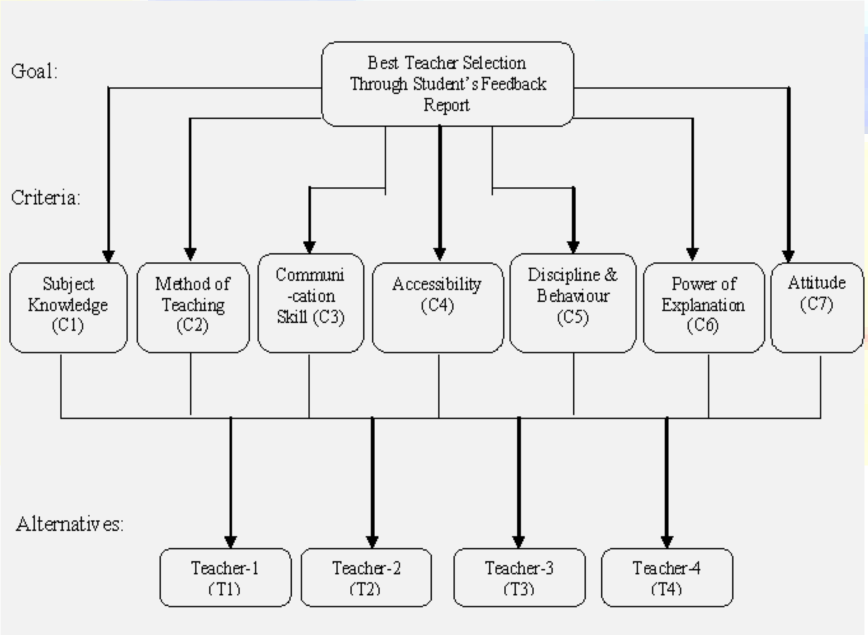
An AHP hierarchy has at least three levels:

Level-1: The main objective or goal or target of the problem at the top.

Level-2: Multiple criteria that define alternatives in the middle.

Level-3: Competing alternatives at the bottom.

In the given model, AHP hierarchy for best teacher selection through student's feedback report is shown in Fig. 1.



Goal	Criterion	Alternatives
	Subject Knowledge(C_1)	**Teacher-1(T_1)**

Best Teacher Selection	**Method of Teaching(C_2)** **Communication Skill(C_3)** **Accessibility(C_4)** **Discipline & Behavior(C_5)** **Power of Explanation(C_6)** **Attitude(C_7)**	**Teacher-2(T_2)** **Teacher-3(T_3)** **Teacher-4(T_4)**

Fig. 1: Best Teacher Selection Hierarchical structure

B. TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

TOPSIS (the Technique for Order Preference by Similarity to Ideal Solution) was developed by Hwang and Yoon [1981] . The basic concept of this method is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in a geometrical sense.

TOPSIS assumes that each attribute has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to locate the ideal and negative-ideal solutions. The Positive Ideal Solution maximizes the benefit criteria and minimizes the cost criteria, whereas the Negative Ideal Solution maximizes the cost criteria and minimizes the benefit criteria .The Euclidean distance approach is used to evaluate the relative closeness of alternatives to the ideal solution. Thus, the preference order of alternatives is yielded through comparing these relative distances.

In the process of TOPSIS, the performance ratings and the weights of the criteria are given as exact values. Abo-sinna and Amer [12] extend TOPSIS approach to solve multi-objective nonlinear programming problems. Jahanshahloo et al. [14] extends the concept of TOPSIS to develop a methodology for solving multi-criteria decision-making problems with interval data. The steps of TOPSIS model are as follows:

- Construction of normalized decision matrix.
- Construction of weighted normalized decision matrix.
- Determine the Ideal and Negative Ideal Solution.
- Calculate the separation measures.
- Calculate the relative closeness to the ideal solution.
- Rank the preference order.

III. Steps of AHP and TOPSIS METHOD

In this paper we use two step methods. In first step AHP is used for calculating the weights of the criteria as well as the overall weights of the candidates in each attribute. In second step these weights are used in TOPSIS process. Then TOPSIS is applied for the evaluation problem and the result shows the preference order of the teachers in an educational institution.

AHP Steps:

I. : Select Experts
II. : Identify the Attributes and Criteria
III. : Identify the Alternatives
IV. : Design the Hierarchical structure.
V. : Establish the pair-wise comparison of the Criteria
VI. : Calculate the Eigen value and Eigen vector
VII. : Perform the Consistency Test
VIII. : Calculate the weights (priority or significance) of the Criteria
IX. : Establish the pair-wise comparison of the Alternatives with respect to each Criteria.
X. : Calculate the Eigen value and Eigen vector for each of them.
XI. : Perform the Consistency Test
XII. : Calculate the weights of the Alternatives for each Criteria
XIII. : Calculate the Geometric Mean(GM) of the weights calculated by Experts
XIV. : Calculate the Eigen value and Eigen vector
XV. : Perform the Consistency Test
XVI. : Calculate the overall weights of the Alternatives.

TOPSIS Steps:

XVII : Start TOPSIS using the weights calculated using AHP.

XVIII: Calculate negative and positive ideal solutions & separation measures.

XIX: Rank the preference.

IV. Data, Experiments & Model Results

Students give their feedback for each teacher for each criterion which is shown in the Table 3.

TABLE 3: 10- Students Feedback against Teacher

Criteria						Subject Knowledge (C1)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	VG	NG	VG	E	EG	E	EG	EG	E
T2	EG	EG	NG	EG	E	EG	VG	E	E	E
T3	G	G	G	VG	VG	G	VG	E	VG	E
T4	VG	G	NG	VG	E	EG	E	EG	EG	E
Criteria						Method of Teaching (C2)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	G	G	G	G	VG	E	VG	VG	E
T2	NG	B	NG	B	B	VG	E	VG	NG	EG
T3	E	EG	E	EG	EG	G	E	EG	E	E
T4	G	G	E	G	G	VB	G	V	G	E

			G					G		G
Criteria						Communication Skill (C3)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	E	EG	EG	EG	G	G	VG	G	VG
T2	EG	E	E	E	EG	EG	VG	G	VG	EG
T3	G	EG	VG	EG	VG	G	B	G	NG	G
T4	VG	E	VG	EG	EG	G	G	VG	G	VG
Criteria						Accessibility (C4)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	G	G	G	G	G	VG	G	G	VG
T2	E	G	E	EG	EG	G	G	VG	E	VG
T3	VG	G	EG	G	EG	G	VG	G	G	VG
T4	G	NG	EG	B	NG	NG	NG	G	NG	G
Criteria						Discipline & Behavior (C5)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	VG	E	G	EG	VG	G	G	G	E

T2	EG	EG	E	EG	E	VG	VG	G	VG	EG
T3	VG	VG	E	EG	EG	G	G	VG	G	E
T4	VG	NG	E	G	E	VG	E	G	G	E
Criteria						Power of Explanation (C6)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	EG	G	E	VG	E	E	E	E	EG
T2	NG	G	B	VG	NG	VG	VG	VG	VG	G
T3	G	G	NG	EG	G	EG	G	EG	EG	VG
T4	VG	EG	G	EG	G	EG	E	EG	E	EG
Criteria						Attitude (C7)				
Teacher	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
T1	VG	VG	G	EG	NG	G	G	VG	G	EG
T2	G	NG	B	VG	B	VG	G	G	NG	VG
T3	EG	EG	VG	E	NG	VG	VG	EG	VG	E
T4	EG	EG	VG	EG	G	VG	VG	VG	VG	EG

According our methodology the model steps:

Start of AHP method:

Step-1: From the Table 3. taking the pair wise comparison matrix A according to Saaty's scale mentioned in table-1 of Student-1 for the criteria Subject Knowledge (C_1) is as follows:-

TABLE 4: Pair Wise Comparison Judgment Matrix for C1

Criterion-1	T1	T2	T3	T4
T1	1.00000	0.50000	2.00000	1.00000
T2	2.00000	1.00000	4.00000	3.00000
T3	0.50000	0.25000	1.00000	0.50000
T4	1.00000	0.33333	2.00000	1.00000

Step-2: Calculate the column sum $\sum_i C_{ij}$ for each column in the table 5.

TABLE 5: Column Sum for C_1

Criterion-1	T1	T2	T3	T4
T1	1.00000	0.50000	2.00000	1.00000
T2	2.00000	1.00000	4.00000	3.00000
T3	0.50000	0.25000	1.00000	0.50000
T4	1.00000	0.33333	2.00000	1.00000
Sum	4.50000	2.08333	9.00000	5.50000

Step-3: Standardized each cell by $X_{ij} = C_{ij} / \sum_i C_{ij}$

TABLE 6: Standardized Matrix for C1

Criterion-1	T1	T2	T3	T4
T1	0.22222	0.24000	0.22222	0.18182
T2	0.44444	0.48000	0.44444	0.54545
T3	0.11111	0.12000	0.11111	0.09091
T4	0.22222	0.16000	0.22222	0.18182

Step-4: Calculate row sum by $\mathbf{R_i}$ □ □$\mathbf{X_{ij}}$

and weight **j**

$\mathbf{W_i = R_i/n}$; **n = no. of candidates = 4.**

TABLE 7: The Row Sum and Weight

Criterion-1	T1	T2	T3	T4	Sum	W
T1	0.22222	0.24000	0.22222	0.18182	0.86626	0.21657
T2	0.44444	0.48000	0.44444	0.54545	1.91434	0.47859
T3	0.11111	0.12000	0.11111	0.09091	0.43313	0.10828
T4	0.22222	0.16000	0.22222	0.18182	0.78626	0.19657

Step-5: Calculate the priority vector by $\mathbf{V_i}$ □$\mathbf{A.W_i}$ **for i =1,2,..,n.**

TABLE 8: Priority Vector (P.Vector) Calculation

Criterion-1	T1	T2	T3	T4	W	P.Vector
T1	1.00000	0.50000	2.00000	1.00000	0.2166	0.8690
T2	2.00000	1.00000	4.00000	3.00000	0.4786	1.9346
T3	0.50000	0.25000	1.00000	0.50000	0.1083	0.4345
T4	1.00000	0.33333	2.00000	1.00000	0.1966	0.7892
Sum	4.5000	2.0833	9.0000	5.5000	1.0000	4.0273

Step-6: Calculate □□□ $\mathbf{V_i / W_i}$ and calculate □ max byaveraging the □ i's in the table 9 given below.

TABLE 9: CALCULATION OF □$_{\mathbf{max}}$

Criterion-1	T1	T2	T3	T4	W	P.Vector	Lamda(□	□Max
T1	1.00000	0.50000	2.00000	1.00000	0.2166	0.8690	4.0125	4.0206
T2	2.00000	1.00000	4.00000	3.00000	0.4786	1.9346	4.0422	
T3	0.50000	0.25000	1.00000	0.50000	0.1083	0.4345	4.0127	

T4	1.00000	0.33333	2.00000	1.00000	0.1966	0.7892	4.0150
Sum	4.5000	2.0833	9.0000	5.5000	1.0000	4.0273	

Step-7: Calculate Consistency Index (C.I) which measures the consistency degree of judgment matrix and Consistency Ratio (C.R) which measures the overall consistency of pair-wise comparison matrices.

Here **C.I.= (λ_{max} - n)/(n-1)= 0.006867** and **C.R. = C.I/R.I = 0.007722**

This value of C.R is less than the allowable value of 0.10.

Therefore, the overall weights are acceptable; it means that weights can really reflect the relative importance of decision making. But if the consistency ratio is greater than 0.10 we should adjust the value of pair-wise comparison matrices and recalculate CR until CR<0.1.

Step-8: Repeat Step-1 to Step- 7 for Student-2 to Student-10 and check the consistency ratio for every judgment matrix.

Step-9: Calculate the Geometric mean (GM) of each cell of Student-1 to Student-10 and repeat Step -1 to Step -7 for calculating the overall weight for each teacher for the criteria Subject Knowledge (C1).

The weight for each teacher against the criteria C1 is shown in Fig. 2.

TABLE 10: Overall Weight of the Teachers

Overall	W
T1	0.256569
T2	0.343071
T3	0.159836
T4	0.240524

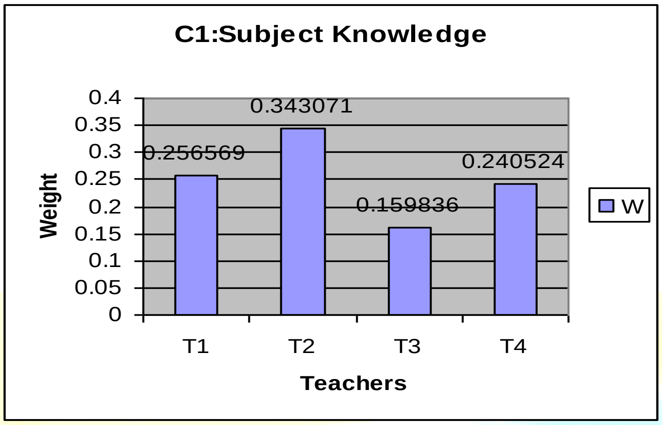


Fig. 2: Weight of teachers for criteria C1

Step -10**:** Repeat Step-1 to Step-9 for each criterion and calculate the weights for each teacher according to each criterion and calculate the weight of each criterion by step- 1 to step- 7

TABLE 11: Overall Weight of the Teachers

Weight	**0.30952**	**0.20661**	**0.10786**	**0.06532**	**0.10106**	**0.16433**	**0.04529**
Teacher	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
T1	**0.256569**	**0.246876**	**0.24882**	**0.227471**	**0.220544**	**0.385853**	**0.19872**
T2	**0.343071**	**0.121642**	**0.38312**	**0.388753**	**0.318419**	**0.121412**	**0.115023**
T3	**0.159836**	**0.477826**	**0.134167**	**0.255007**	**0.252768**	**0.188865**	**0.356665**
T4	**0.240524**	**0.153656**	**0.233893**	**0.128769**	**0.208269**	**0.303871**	**0.329592**

The weights for each teacher against the other criteria C2, C3, C4, C5, C6 and C7 are shown in figures below:

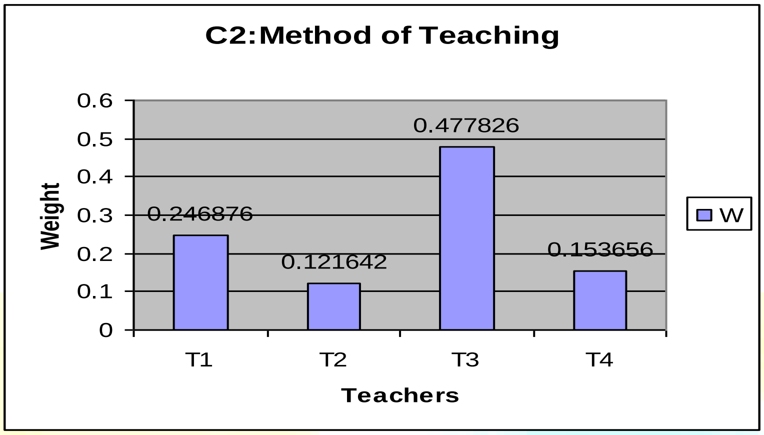


Fig. 3: Weight of teachers for criteria C2

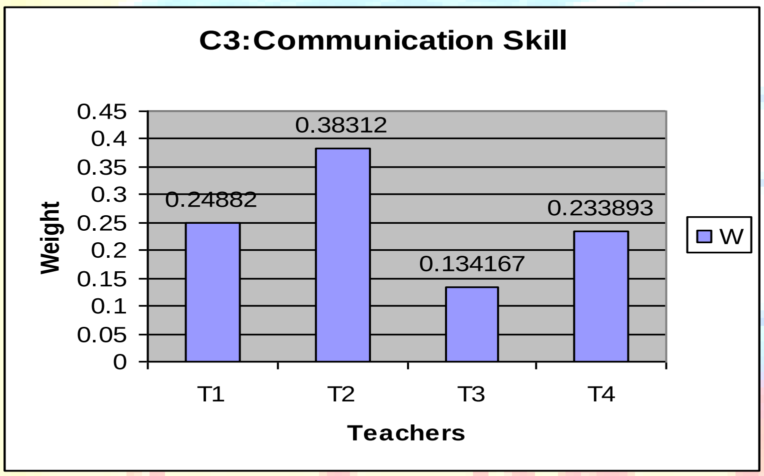


Fig. 4: Weight of teachers for criteria C3

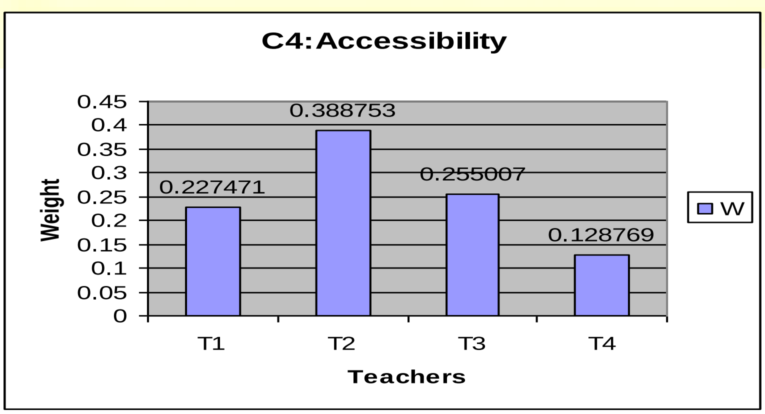


Fig. 5: Weight of teachers for criteria C4

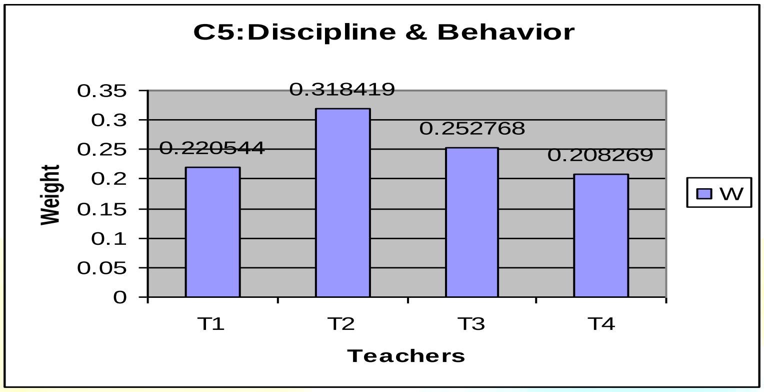


Fig. 6: Weight of teachers for criteria C5

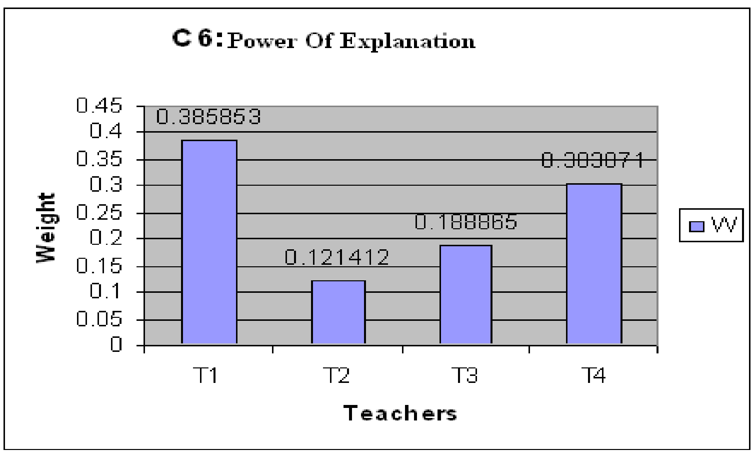


Fig. 7: Weight of teachers for criteria C6

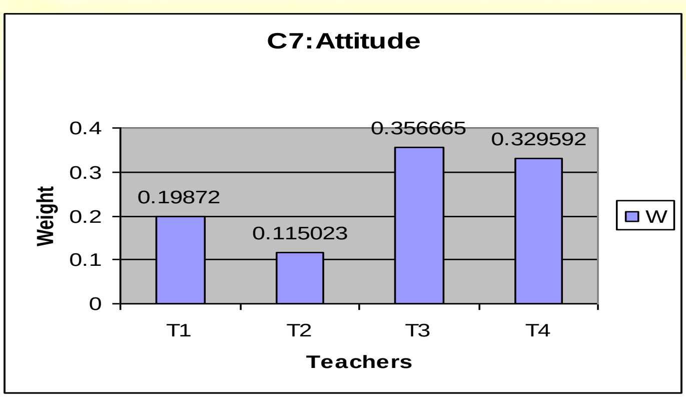


Fig. 8: Weight of teachers for criteria C7

TOPSIS method :

Step -11: Construct normalized decision matrix.

Normalize data as follows:

$$r_{ij} = x_{ij} / (\sum_i x^2_{ij})^{1/2} \quad \text{for } i = 1, \ldots, m;\ j = 1, \ldots, n$$

Table 12: Normalized Decision Matrix

WEIGHT	0.30952	0.20661	0.10786	0.06532	0.10106	0.16433	0.04529
TEACHER	C1	C2	C3	C4	C5	C6	C7
T1	0.065828	0.060948	0.061911	0.051743	0.04864	0.148883	0.03949
T2	0.117698	0.014797	0.146781	0.151129	0.101391	0.014741	0.01323
T3	0.025548	0.228318	0.018001	0.065029	0.063892	0.03567	0.12721
T4	0.057852	0.02361	0.054706	0.016581	0.043376	0.092338	0.108631
SUM	0.26692	0.32767	0.28140	0.28448	0.25730	0.29163	0.28856
SQ.ROOT	0.51665	0.57243	0.53047	0.53337	0.50725	0.54003	0.53718

WEIGHT	0.30952	0.20661	0.10786	0.06532	0.10106	0.16433	0.04529
TEACHER	C1	C2	C3	C4	C5	C6	C7
T1	0.496604	0.43128	0.469055	0.42648	0.434788	0.714505	0.369933
T2	0.664033	0.212502	0.722227	0.728864	0.627741	0.224825	0.214124
T3	0.309371	0.834737	0.252921	0.478107	0.498315	0.349731	0.66396
T4	0.465548	0.268429	0.440916	0.241426	0.410588	0.562694	0.613561

Step -12: Construct the weighted normalized decision matrix

Multiply each column of the normalized decision matrix by its associated weight (w_j). An element of the new matrix is: $v_{ij} = w_j\, r_{ij}$

TABLE 13: Weighted Normalized Decision Matrix

WEIGHT	0.30952	0.20661	0.10786	0.06532	0.10106	0.16433	0.04529

TEACHER	C1	C2	C3	C4	C5	C6	C7
T1	0.153709	0.089107	0.050592	0.027858	0.04394	0.117415	0.016754
T2	0.205531	0.043905	0.077899	0.047609	0.06344	0.036946	0.009698
T3	0.095757	0.172465	0.02728	0.03123	0.05036	0.057471	0.030071
T4	0.144096	0.05546	0.047557	0.01577	0.041494	0.092468	0.027788

Step -13: Determine the Ideal and the Negative ideal solutions.

For the benefit criteria, the decision maker wants to have a maximum value among the alternatives. For the cost criteria, the decision maker wants to have a minimum value among alternatives. Obviously, A* indicates the most preferable alternative or ideal solution. Similarly, A' indicates the least preferable alternative or negative-ideal solution.

Ideal solution

A* = {v1* , …, vn*}, where

$$V_j^* = \{\max_i(v_{ij}) \text{ if } j \in J; \min_i(v_{ij}) \text{ if } j \in J'\}$$

= {0.205531, 0.172465, 0.077899, .047609, 0.06344, 0.117415, 0.030071}

Negative ideal solution

A' = {v1' , …, vn' }, where

$$v_j' = \{\min_i(v_{ij}) \text{ if } j \in J ; \max_i(v_{ij}) \text{ if } j \in J'\}$$

= {0.095757, 0.043905, 0.02728, 0.01577, 0.041494, 0.036946, 0.009698}

Step -14: Calculate the separation measures.

The N-dimensional Euclidean distance method is next applied to measure the separation distances of each alternative to the ideal solution and negative-ideal solution.

The separation from the ideal alternative is:

$$S_i^* = [\sum_j (v_j^*-v_{ij})^2]^{1/2} \quad ; i = 1, \ldots, m$$

TABLE 14: Separation Measure from Ideal Alternative

Teacher	C1	C2	C3	C4	C5	C6	C7	Sum	Si*
T1	0.002686	0.006949	0.000746	0.00039	0.00038	0	0.000178	0.011329	0.106438
T2	0	0.016528	0	0	0	0.006475	0.000415	0.023418	0.153029
T3	0.01205	0	0.002562	0.000268	0.000171	0.003593	0	0.018644	0.136543
T4	0.003774	0.01369	0.000921	0.001014	0.000482	0.000622	0.000005	0.020508	0.143206

Similarly, the separation from the Negative ideal alternative is:

$$S'i = = [\square\ (v_j' - v_{ij})^2)\ ]^{1/2} \qquad ; i = 1, \ldots, m$$

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TEACHER	C1	C2	C3	C4	C5	C6	C7	Sum	Si'
T1	0.003358	0.002043	0.000543	0.000146	0.000006	0.006475	0.00005	0.012621	0.112343
T2	0.01205	0	0.002562	0.001014	0.000482	0	0	0.016108	0.126917
T3	0	0.016528	0	0.000239	0.000079	0.000421	0.000415	0.017682	0.132974
T4	0.002337	0.000134	0.000411	0	0	0.003083	0.000327	0.006292	0.079322

Step -15: Compute the relative closeness to the ideal solution

Relative closeness Ci* and the corresponding rank of the candidate.

$C^*_i = S^*_i\ /(\ S^*i\ _+\ S'i\ );\ 0 \leq C^*i \leq 1\ ,I = 1,2,3\ldots\ M$

Apparently, $C^*_{i\ =}1$,if A_i=A^* and C_i-=0,if A_i=A^-

Step-16 :Rank the preference order

The best satisfied alternative can now be decided according to preference rank order of Ci*. Therefore, the best alternative is the one that has the shortest distance to the ideal solution. The relationship of alternatives reveals that any alternative which has the shortest distance to the ideal solution is guaranteed to have the longest distance to the negative-ideal solution.

TABLE 16: RELATIVE CLOSENESS AND RANK OF TEACHERS

Teacher	Result	Rank
T1	0.51349	1
T2	0.45336	3
T3	0.49337	2
T4	0.35645	4

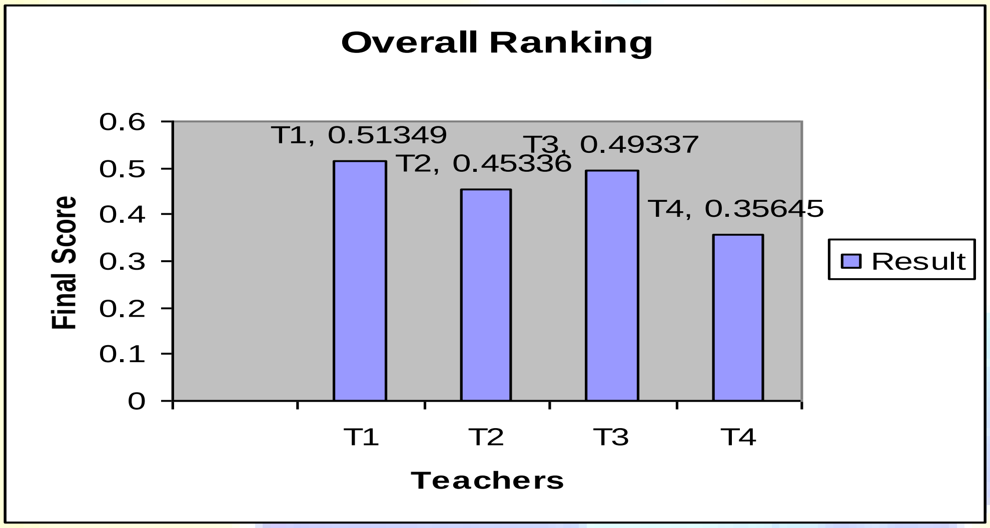

Fig. 9: Overall ranking

V. CONCLUSIONS

There is no doubt that many real life problems can be dealt with as MCDM problems. Although the mathematical procedures for processing the pertinent data are rather simple, the real challenge is in quantifying these data. In matter of fact, it is not even a well defined problem. The main problem is that often nobody can know what the optimal alternative is. Operations research provides a systematic framework for dealing with such problems.

The AHP is a useful technique for discriminating between competing options in the light of a range of objectives to be met. Proposed paper concludes that the teacher T1 is best in his performance and followed by teacher T3 and teacher T2. The overall performance of the teacher T4 is not good enough with respect to different criteria among all other teachers. It is notable that the subject knowledge of the teacher T2 is better than the teachers T1 & T3 and T4 is also better than T3. This article introduces an approach that integrates AHP with TOPSIS algorithm.

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