Combinatorial Mathematics Based Approach in Assessment of a Professor in Technical Institute

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***Abstract* - This paper studies the adaption of Combinatorial mathematics based approach to evaluate the performance of a professor in technical institution. The qualitative and quantitative attributes are converted into crisp scores using fuzzy scale. The factors that influence the performance evaluation are assigned with weights to prioritize and the Index score was evaluated using Permanent function**

***Index Terms* - Combinatorial mathematics, Assessment, Permanent function, Index score.**

I. INTRODUCTION

Professors are made, not born. One of the most significant change in engineering education in India is the paradigm shift from teacher centre to student centre. In improving the quality of education, the evaluation of the structure of the academics and teaching methods are essential and also to encourage better job performance. Meaningful evaluation involves an accurate appraisal of effectiveness of teaching, strengths and areas for development. For professional development feedback, coaching, support and opportunities are to be provided. In general, the conventional evaluation system demonstrates the practice of evaluation through the multiple, detailed classroom observations and also through the review of work products, as the present day scenario in teaching is that an academician is just a facilitator. The evaluation of performance not only helps to analyze the achievements of institution and individual, but also to evaluate the individual's contribution to the attainment of objectives of the institution, as it is done in a systematic way. Academicians see the performance evaluation process as a motivation tool to strengthen the personal and organizational growth [1]. The study of performance appraisal by traditional methods was carried out by [2] which throws light on the usage of traditional methods like ranking, graphic rating scale, critical incident, forced choice method and narrative essays which are standard in teacher evaluation system. Pavani et al [3] proposed a fuzzy logic based performance evaluation system, where in, definite conclusions were drawn from vague, ambiguous or imprecise information. To analyze the performance of teacing staff, Kamath [4] developed a computer model based on fuzzy set theory incorporating an alternative way of thinking which allows modeling complex systems using a higher level of abstraction originating from human knowledge and experience. The performance appraisal of faculty in higher education institutions was carried out by Mamatha et al [5]. Fuzzy terms and fuzzy concepts were adapted in their model to measure the ability, competence and skills of faculty. An algorithm was developed in visual basics and implemented in Matlab fuzzy logic tool box to predict the weight of various categories in evaluating the faculty performance.

Babak and Turan [6] adapted fuzzy analytic hierarchy process in selection of academic staff. Ten criteria namely Foreign language, Bachelor's degree, oral presentations, Academic experience, Research papers, Technical information, Team working, Self-confidence, Compatibility and age were chosen based on literature and the above criteria were prioritized. The most appropriate candidate for the position of academic staff was selected based on the result score as the-bigger-the-better. Aly et al [7] developed a performance evaluation model based on AHP-TOPSIS and balanced score card approach to prioritize the faculty in an educational institution. In their model, balanced scorecard was adapted to measure the performance of the faculty of engineering taking into account, the strategic objectives and the importance of the strategic objectives were obtained using AHP-TOPSIS. It was concluded that their model provide a wider development of metrics that are closely connected to the strategic goals of the institution. Yee and Chen [8] proposed a performance appraisal system using multi-factorial evaluation model to evaluate the performance appraisal criteria of staff of an Information and communication technology based company. Bhosale and Kamath [9] developed a fuzzy inference system for performance appraisal of teaching staff. Mamdani type inference was adapted to evaluate the fuzziness and center of gravity defuzzification method was adapted to de-fuzzify the resulting fuzzy set.

In this study, a Combinatorial Mathematics Based Approach (CMBA) is adapted to evaluate the performance of professor in a technical education. The objective of the evaluation procedure is to identify the professor selection factors and obtain the factors that influence the growth of an academician and in-turn the educational institution.

II. COMBINATORIAL MATHEMATICS BASED APPROACH

Combinatorial mathematics based approach is an integration of analytic hierarchy process and a combinatorial mathematics matrix function [10]. The factors that influence the performance of professor are research expertize, research paper publications both in quantity and quantity wise, books authored, academic contributions, administrative contributions, teaching and learning, guidance in projects to graduates and research scholars, teaching methodologies, updating course structure and curriculum, ability to work with other people, grant income, professional development activities, responsibility for student welfare counselling and discipline, organization of faculty development programs seminars conferences and workshops, consultancy projects.

Decision matrix

A professor assessment matrix is formulated considering Research paper publications (C1), Projects undertaking (C2), Project grant (C3), Guiding research scholars (C4), Students feedback (C5), Consultancy projects (C6) as attributes. It is to be noted that the attributes may be subjective or objective. The eleven point fuzzy scale is used to convert subjective attributes into crisp scores [10]. The values of attributes are shown in Table 1 and the conversion of linguistic terms into simple crisp scores is shown in Table 2 [10].

Table 1. Professor assessment attributes

S. no	Professor name	C 1 (Nos.)	C 2 (Nos.)	C 3 (Rs)	C 4 (Nos.)	C 5	C 6 (Nos.)
1	A 1	12	4	7200000	2	Excellent	2
2	A 2	13	2	280000	1	Very Good	1
3	A 3	10	6	6450000	4	Excellent	1
4	A 4	8	1	230000	3	Good	1
5	A 5	14	3	9200000	4	Above average	1
6	A 6	9	2	3400000	1	Good	1
7	A 7	11	3	6800000	3	Very Good	1
8	A 8	10	2	5300000	4	Good	1
9	A 9	13	1	3200000	3	Good	2
10	A 10	16	2	7800000	4	Excellent	1

Table 2. Conversion of linguistic terms into crisp scores

Linguistic term	Fuzzy score	Simple score
Exceptionally low	0.0455	0.0
Extremely low	0.1364	0.1
Very low	0.2273	0.2
Low	0.3182	0.3
Below average	0.4091	0.4
Average	0.5000	0.5
Above average	0.5909	0.6
High	0.6818	0.7
Very high	0.7727	0.8
Extremely high	0.8636	0.9
Exceptionally high	0.9545	1.0

Normalization matrix

The professor assessment matrix is deduced which, gives the inter-relationships among the attributes. The size of the matrix is equal to the number of attributes considered. Normalization is to set the attribute data on same scale so that, comparisons can be made easier [11]. Let xij is the normalized value of yij for attribute i, then,

$$x_{ij} = \frac{y_{ij}}{\max_j (y_{ij})} \text{ ; if jth attribute is beneficial}$$

$$x_{ij} = \frac{\min_j (y_{ij})}{y_{ij}} \text{ ; if, jth attribute is non-beneficial}$$

The normalized values of attributes is shown in Table 3.

Table 3. Normalized values of attributes

S. no	Professor name	C 1 (Nos.)	C 2 (Nos.)	C 3 (Rs)	C 4 (Nos.)	C 5	C 6 (Nos.)
1	A 1	0.750	0.667	0.783	0.500	1.00	1.00
2	A 2	0.813	0.333	0.030	0.250	0.89	0.50
3	A 3	0.625	1.000	0.701	1.000	1.00	0.50
4	A 4	0.500	0.167	0.025	0.750	0.79	0.50
5	A 5	0.875	0.500	1.000	1.000	0.68	0.50
6	A 6	0.563	0.333	0.370	0.250	0.79	0.50
7	A 7	0.688	0.500	0.739	0.750	0.89	0.50
8	A 8	0.625	0.333	0.576	1.000	0.79	0.50
9	A 9	0.813	0.167	0.348	0.750	0.79	1.00
10	A 10	1.000	0.333	0.848	1.000	1.00	0.50

Relative importance of attributes

After analyzing the attributes, the relative importance of attributes is assigned. Table 4 shows the scale for pairwise comparison [11, 12].

Table 4. Scale for pairwise comparison

Degree of importance	Definition
1	Equal
2	Intermediate between 1 and 3
3	Moderately preferable
4	Intermediate between 3 and 5
5	Strongly preferable
6	Intermediate between 5 and 7
7	Very strongly preferable
8	Intermediate between 7 and 9
9	Extremely strongly preferable
½, 1/3, ¼, 1/5, 1/6, 1/7, 1/8, 1/9	Reciprocals of 2, 3, 4, 5, 6, 7, 8 and 9

The geometric mean approach of AHP is used to determine the relative normalized weights of the attributes and the consistency check is carried out. It is required that the consistency ratio value of the relative importance of attributes should be less than 0.10 [13]. The consistency ratio in the present study is found to be 0.093. The consistency evaluation is shown in Table 5.

Table 5. Consistency evaluation

	C 1	C 2	C 3	C 4	C 5	C 6	Total	Average	Consistency Measure
C 1	0.375	0.559	0.331	0.283	0.21	0.27	2.021	0.337	6.717
C 2	0.125	0.186	0.331	0.283	0.26	0.20	1.383	0.230	6.850
C 3	0.188	0.093	0.166	0.283	0.26	0.13	1.120	0.187	6.819
C 4	0.125	0.062	0.055	0.094	0.21	0.20	0.742	0.124	6.505
C 5	0.094	0.037	0.033	0.024	0.05	0.13	0.372	0.062	6.146
C 6	0.094	0.062	0.083	0.031	0.03	0.07	0.363	0.060	6.405
							CI		0.115
							RI		1.24
							CR		0.093

Alternative selection matrix for each alternative

The alternative professor selection matrix is formed by keeping the normalized values for attributes for the alternative as diagonal elements. The matrix is represented by, B.

$$B = \begin{bmatrix} D_1 & d_{12} & d_{13} & d_{14} & d_{15} & d_{16} \\ d_{21} & D_2 & d_{23} & d_{24} & d_{25} & d_{26} \\ d_{31} & d_{32} & D_3 & d_{34} & d_{35} & d_{36} \\ d_{41} & d_{42} & d_{43} & D_4 & d_{45} & d_{46} \\ d_{51} & d_{52} & d_{53} & d_{54} & D_5 & d_{56} \\ d_{61} & d_{62} & d_{63} & d_{64} & d_{65} & D_6 \end{bmatrix} \quad (1)$$

Permanent function

The permanent function used in Combinatorial mathematics characterizes the configuration of a system [14]. The characteristic permanent function for the standard matrix is shown in Eq. 2.

$$\begin{aligned}
&Per(B) = \\
&\prod_{i=1}^{M} D_i + \sum_{i=1}^{M-1}\sum_{j=i+1}^{M} \dots\dots\dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{ji})D_kD_lD_mD_nD_o....D_tD_m \\
&+\sum_{i=1}^{M-2}\sum_{j=i+1}^{M-1}\sum_{k=j+1}^{M} \dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{ki}+d_{ik}d_{kj}d_{ji})D_lD_mD_nD_o....D_tD_M \\
&+[\sum_{i=1}^{M-3}\sum_{j=i+1}^{M}\sum_{k=i+1}^{M-1}\sum_{l=i+2}^{M} \dots\dots\dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{ji})(d_{kl}d_{lk})D_mD_nD_o.....D_tD_M + \\
&\sum_{i=1}^{M-3}\sum_{j=i+1}^{M-1}\sum_{k=i+1}^{M}\sum_{l=j+1}^{M} .... \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{kl}d_{li}+d_{il}d_{lk}d_{kj}d_{ji})D_mD_nD_o.....D_tD_m] \\
&+[\sum_{i=1}^{M-2}\sum_{j=i+1}^{M-1}\sum_{k=j+1}^{M}\sum_{l=1}^{M-1}\sum_{m=l+1}^{M} \dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{ki}+d_{ik}d_{kj}d_{ji})(d_{lm}d_{ml})D_nD_o......D_tD_m \\
&+\sum_{i=1}^{M-4}\sum_{j=i+1}^{M-1}\sum_{k=i+1}^{M}\sum_{l=i+1}^{M}\sum_{m=j+1}^{M} \dots\dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{kl}d_{lm}d_{mi}+d_{im}d_{ml}d_{lk}d_{kj}d_{ji})D_nD_o......D_tD_m] \\
&+[\sum_{i=1}^{M-3}\sum_{j=i+1}^{M-1}\sum_{k=i+1}^{M}\sum_{l=j+1}^{M}\sum_{m=1}^{M-1}\sum_{n=m+1}^{M} \dots\dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{kl}d_{li}+d_{il}d_{lk}d_{kj}d_{ji})(d_{mn}d_{nm})D_o......D_tD_m \\
&+\sum_{i=1}^{M-5}\sum_{j=i+1}^{M-1}\sum_{k=j+1}^{M}\sum_{l=1}^{M-2}\sum_{m=l+1}^{M-1}\sum_{n=m+1}^{M} \dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{ki}+d_{ik}d_{kj}d_{ji})(d_{lm}d_{mn}d_{nl}+d_{\ln}d_{nm}d_{ml})D_o.......D_tD_m \quad (2) \\
&+\sum_{i=1}^{M-5}\sum_{j=i+1}^{M}\sum_{k=i+1}^{M-3}\sum_{l=i+2}^{M}\sum_{m=k+1}^{M-1}\sum_{n=k+2}^{M} \dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{ji})(d_{kl}d_{lk})(d_{mn}d_{nm})D_o.......D_tD_m \\
&+\sum_{i=1}^{M-5}\sum_{j=i+1}^{M-1}\sum_{k=i+1}^{M}\sum_{l=i+1}^{M}\sum_{m=i+1}^{M}\sum_{n=j+1}^{M} \dots\dots \sum_{M=t+1}^{M}(d_{ij}d_{jk}d_{kl}d_{lm}d_{mn}d_{ni}+d_{in}d_{nm}d_{ml}d_{lk}d_{kj}d_{ji})D_o.....D_tD_m] \\
&+\dots\dots\dots\dots\dots\dots
\end{aligned}$$

Rank of alternatives

The rank of alternatives are based on the permanent function value of the alternative professor selection matrix, also called as Index score. The alternative for which the value of Index score is highest is the best choice for the considered decision making problem. The Index score for all alternatives is sorted and ranked as shown in Table 6.

Table. 6 Index score for professors

S. No	Professor name	Index score	Rank
1	A1	0.4714	2
2	A2	0.0505	10

3	A3	0.4987	1
4	A4	0.0589	9
5	A5	0.3574	4
6	A6	0.0652	8
7	A7	0.2547	5
8	A8	0.1917	6
9	A9	0.1801	7
10	A10	0.3767	3

III. CONCLUSION

The proposed CMBA is relatively a new approach in assessment of professor in an educational institution. The computation used is comparatively simple compared to other multi attribute decision making methods. The measures of the attributes and their relative importance are used together to rank the alternatives. Hence, it provides a better evaluation. The use of permanent concept characterizes the considered approach as it contains all possible structural components of the attributes and their relative importance hence, no information is lost. This method can deal with problems considering both qualitative and quantitative attributes. The uniqueness of CMBA is that it offers a general procedure that can be applicable to diverse selection problems that incorporates vagueness and a number of selection attributes. The approach is logical, simple and convenient to implement.

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