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AN INTEGRATED APPROACH OF MULTI-CRITERIA GROUP DECISION MAKING TECHNIQUES TO EVALUATE THE OVERALL PERFORMANCE OF TEACHERS

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Abstract: Teaching is not just an act of intelligence; it is a legacy of association, legacy of effort, legacy of priority and legacy of moral and ethical standards. A person is nurtured by his parents since his birth, school mates, society and others. It is very essential for an education institution to focus on the realistic insight of a student. The very essence to comprehend purely depends on the basis of how a teacher imprints the impact of learning into an understandable status for a student. To be a teacher, knowledge of a sphere is not only the requirement for representation, but also a supporting plan for an individual to remain in the sphere of learning. Continued learning is the key tool for teachers, since updating the knowledge has to be the basic criterion for a teacher to discover his/her credibility. So, higher education learning institutions and the government in particular, has increasingly wanted to be assured of the quality in overall performances of a teacher. In getting this assurance, universities, therefore have to produce tangible evidence of the quality of teachers they provide. Analysing the performance of a teacher is an important part of education system. It plays a crucial role in improving overall qualities and arousing enthusiasm of the teacher. Therefore it is one of the great implication to design a new mathematical model to analyze the performance of a teacher based on the existing information system. In this paper a study has been made by using multi-criteria decision making with the help of six methodologies containing AHP, Fuzzy AHP, COPRAS, TOPSIS, Cooperative Game Theory and Compromise Programming. Several expert opinions are considered to compare between the teachers and at last determines the rank using group decision making method.

Keywords: AHP, Fuzzy AHP, COPRAS, TOPSIS, Cooperative Game Theory, Compromise Programming, Spearman's Rank Correlation Coefficient and Group Decision Making .

I. INTRODUCTION

Agrell and Steuer [1] developed a multi-criteria decision support system for the performance review of individual faculty. They proposed a multi criteria evaluation system for individual faculty member's performance. Mesak and Jauch [2], developed a model by which college and university administrators might evaluate performances of major components of a faculty work, i.e., research, teaching, and service. Ellington and Ross [3] proposed a teaching evaluation scheme to assess the university teachers in the Robert Gordon University. This scheme was based on a teaching skills profile that enables academic staff to undertake self-rating in respect of a set of basic criteria for effective performance in teaching and related activities.

The report of the National Accreditation and Assessment Council (NAAC, 2008), shows that only 30 percent of universities and 10 percent of the colleges are with 'A' grade or "Five star" institutions and the rest are tolerable or poor. Maintaining and improving quality of higher education is a great challenge in India (Muzammil.M, 2010). Performance linked development system having validity and reliability will be a key factor for quality assurance and quality sustainability in engineering colleges. The performance appraisal system plays a major role in retaining quality faculty in the institution (Pandit, R.K. 2008**)**. Enrichment of overall academic and research standards of Higher Educational Institutions can be achieved through changes in Performance Appraisal practices [4].

Multi Criteria Decision Making Approach provides better idea to analyze the performance of a teacher of educational institutions. Pairwise comparison method like Analytical Hierarchy Process (AHP) developed by Saaty [5, 6] in 1980 is very useful to compare the different criterions and the alternatives to analyze the performance of teacher in an educational institution. Fuzzy analytical hierarchy process was developed to tolerate vagueness and uncertainty of human judgment [7]. To improve the lack of recruitment processes as well as reduce individual senses of supervisory level by fuzzy logic and AHP methods, Pin-Chang Chen tries in [8] to identify appropriate personality traits and key professional skills through the information statistics. P. Kousalya and et.al. presented the use of multi criteria decision-making methods for ranking alternatives that curb student absenteeism in engineering college [9]. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) was first developed by Hwang and Yoon [10], is based on the idea that the chosen alternative should have the shortest distance from the positive ideal solution and on the other side the farthest distance of the negative ideal solution. The researchers of Vilnius Gediminas Technical University (Zavadskas, Kaklauskas 1996) has created a method of complex proportional evaluation COPRAS (Complex Proportional Assessment) in 1996. D.N.Ghosh and et.al approaches a new methodology to evaluate the ranking of best engineering college and evaluation of performance of faculty in engineering college and [11, 12]. Compromise Programming (CP) and Cooperative Game Theory (CGT) both defines the best/suitable solution whose point is at the least from an ideal point (Zeleny, 1982; Gershon and duckstein *et al*., 1983; Duckstein *et al*., 1994).

The paper is equipped as follows: Section II emphases about the Experts' opinion, Section III focuses about MCDM techniques using six methodologies for ranking the interview candidates on the basis of several experts' judgment followed by the comparison between the results, Section IV illustrates the final ranking by group decision analysis method and Section V concludes the paper.

II. EXPERTS' OPINION

In this research, the proposed method is applied to analyze the performance of a teacher of an educational institution. Six teachers were examined and randomly selected for the present study. A preliminary literature survey was carried out to identify the criterias and sub criterias. To shortlist the criterias and sub criterias another survey was conducted among Experts' (X,Y), in this field for adding/removing of criterias and sub-criterias. The identified of criterias and sub-criterias are listed below

Criterias:
A. Qualification
B. Knowledge of Subject
C. Leadership and managing power
D. Research and Project production
E. Past Experience

Sub Criterias:
A1. Ph.D completed
A2. Ph.D Pursuing
A3. Non Ph.D
B1. Theoretical
B2. Practical
C1. Communication Skill
C2. Self Development
C3. Mental Stress
D1. Achievement
D2. Project Guidance
D3. Periodic arrangement of seminar and workshop
E1. Academic
E2. Industry

Table I. Experts' opinion against each candidate

Criteria	A						B				C						D						E			
Sub Criteria	A1		A2		A3		B1		B2		C1		C2		C3		D1		D2		D3		E1		E2	
Candidate	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
a	VG	G	E	G	VG	G	B	G	B	E	VG	VG	G	B	A	VG	VG	E	VG	G	VG	VG	G	VG	VG	G
b	G	G	E	A	B	G	G	E	G	G	A	E	G	VG	VG	G	VG	VG	E	A	VG	G	VG	VG	E	VG
c	G	G	G	B	G	G	VG	G	VG	E	E	E	VG	VG	G	G	E	E	VG	E	G	G	E	E	G	G
d	E	VG	G	G	G	B	G	B	B	B	G	E	B	G	A	B	G	G	G	VG	VG	A	G	VG	VG	B
e	A	E	G	A	VG	E	A	B	VG	G	A	VG	A	G	B	B	VG	E	A	G	G	A	E	G	G	VG
f	G	G	VG	VG	A	A	VG	G	G	E	A	A	A	B	G	B	G	VG	VG	A	A	E	VG	G	VG	G

III. TECHNIQUES USED & PROPOSED METHODOLOGY

A. AHP

In literature review we have seen that there are several MCDM techniques in evaluating influencing factors. In this study, we have chosen the evaluation process of influencing factors based on AHP**.** Analytical Hierarchy Process (AHP) is used to calculate the relative importance between the criterion based on expert opinion with the help of Saaty's 9-point linear scale and the detailed steps of AHP was described in our previous work named as "Non-Teaching Staff Performance Analysis Using Multi-Criteria Group Decision Making Approach" [13].

B. Fuzzy AHP

Saaty's AHP method was modified by introducing the fuzzy analysis (i.e. Fuzzy AHP) by Chang's in 1992 [14] and the main drawback of Chang's extent analysis is that the degree of possibility of some criteria was zero. To overcome this problem, Hesham A and et.al. used Gaussian fuzzy number persist of triangular fuzzy number [15] Gaussian functions have the advantage of being fully determined using only two parameters, i.e. center (μ) and width (σ) and its value never equals to zero. Thus, the intersection must be existed between every fuzzy number and all the others. In this case, shortages of the triangular fuzzy number are overcome. We modified the steps of Hesham's Gaussian extent to calculate the relative importance between criteria with the help of the following steps of Figure II.

The definition of Gaussian function is as follows:

Gaussian $(x{:}\mu, \sigma) = exp\left[\frac{-(x-\mu)^2}{\sigma^2}\right]$

At any levelα, as in Fig.1, it is shown that

$$\alpha = exp\left[\frac{-(x-\mu)^2}{\sigma^2}\right]$$

$x_1 = \mu - \sigma \times \sqrt{-ln(\alpha)}$ and

$x_2 = \mu + \sigma \times \sqrt{-ln(\alpha)}$

It is obvious that as long as a level is small enough, then it is feasible to get a good fuzzy triangular approximation of $G(x, \mu, \sigma)$ by $T(x, x_1, \mu, x_2)$. Such an approximation is useful for performing the fuzzy arithmetic operations to get S_i as shown below

$$S_i = \frac{\sum_j G_{ij}}{\sum_i \sum_j G_{ij}} = \frac{\sum_j (L_i^j, M_i^j, N_i^j)}{\sum_i \sum_j (L_i^j, M_i^j, N_i^j)}$$

where

$$L_i^j = M_i^j - \sigma_i^j \sqrt{-ln(\alpha)}$$ and

$$U_i^j = M_i^j + \sigma_i^j \sqrt{-ln(\alpha)}$$

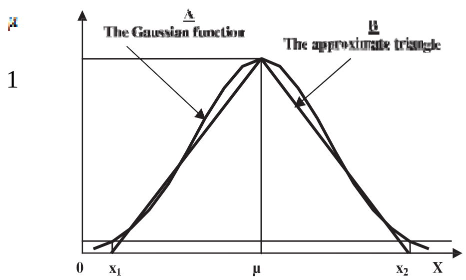

Figure I. Gaussian function A and its approximated triangle B.

To get good triangular approximation, we choose a low level for α. Once, we get S_i's as triangle fuzzy numbers, they can be returned back to Gaussian to present the ranking step.

Several MCDM methods like TOPSIS, COPRAS and Compromise Programming are used in our proposed methodology. The detailed steps of TOPSIS, COPRAS and Compromise Programming are described in our same previous published research work "Non-Teaching Staff Performance Analysis Using Multi-Criteria Group Decision Making Approach" [13].

C. Co-operative Game Theory

Co-operative Game Theory (CGT) is another distance-based approach. In this approach the best suitable alternative is that which maximizes the distance from some reference point of minimum level rather than minimizing the distance to a goal (Gershon and Duckstein, 1983). The distance measure used in CGT is the geometric distance and expressed as

$$g(a) = \prod_{j=1}^{J} \left| f_j(a) - f_j^{**} \right|^{W_j} ,$$

where $g(a)$ = Geometric distance for alternative a,

f_j^{**} is negative ideal value of criterion j.

The detailed steps of Co-operative Game Theory are described by the following proposed methodology.

With the help of above techniques, finally Spearman correlation and coefficient ranking method to determine group decision multi criteria analysis we propose a new technique which provides the perfect result in every case.

D. Spearman rank correlation coefficient

Spearman rank correlation coefficient ℓ is useful to determine the measure of association/correlation (including positive or negative direction of a relationship) between ranks achieved by different MCDM methods and/or different decision-makers and/or different scenarios for a given set of alternatives. If U_a and V_a denote the ranks achieved by above situation(s) for the same alternative a, then ℓ is defined as [14] :

$$\ell = 1 - \frac{6 \sum_{a=1}^{n} d_a^2}{n^3 - n}$$

Where d_a = difference between ranks U_a and V_a achieved by the same alternative a,

n = number of alternatives and $-1 \le \ell \le 1$.

Various critical values for Spearman rank correlation coefficient for various significance level is provided in [15]. Numerous case studies have used the Spearman rank correlation method for computation of correlation coefficient values [16].

Characteristics of correlation coefficient can be explained in Table II. as:

Table II. Characteristics of Co-efficient R

Correlation coefficient value	*Nature of correlation*	*Remark*
0.9 - 1.0	Very High	Very Strong relationship
0.7 – 0.9	High	Marked relationship
0.4 – 0.7	Moderate	Substantial relationship
0.2 – 0.4	Low	Definite relationship
< 0.2	Slight	Small relationship

Our proposed methodology is described in the following Figure II.

IV. RESULTS & DISCUSSION

After using the opinions which are collected by the experts we prepare pay-off matrix and calculate the weights of the attribute by AHP which is shown in Table III.

Introduce Gaussian fuzzy membership function (Fuzzy AHP) which is presented in [17] to overcome Saaty 9 point linear scale into fuzzy scale by considering original AHP decision input into low, mid, high decision and then we build up one modified technique of Chang's extent analysis [18] to evaluate more accurate importance relative between the attributes. It is shown in Table IV.

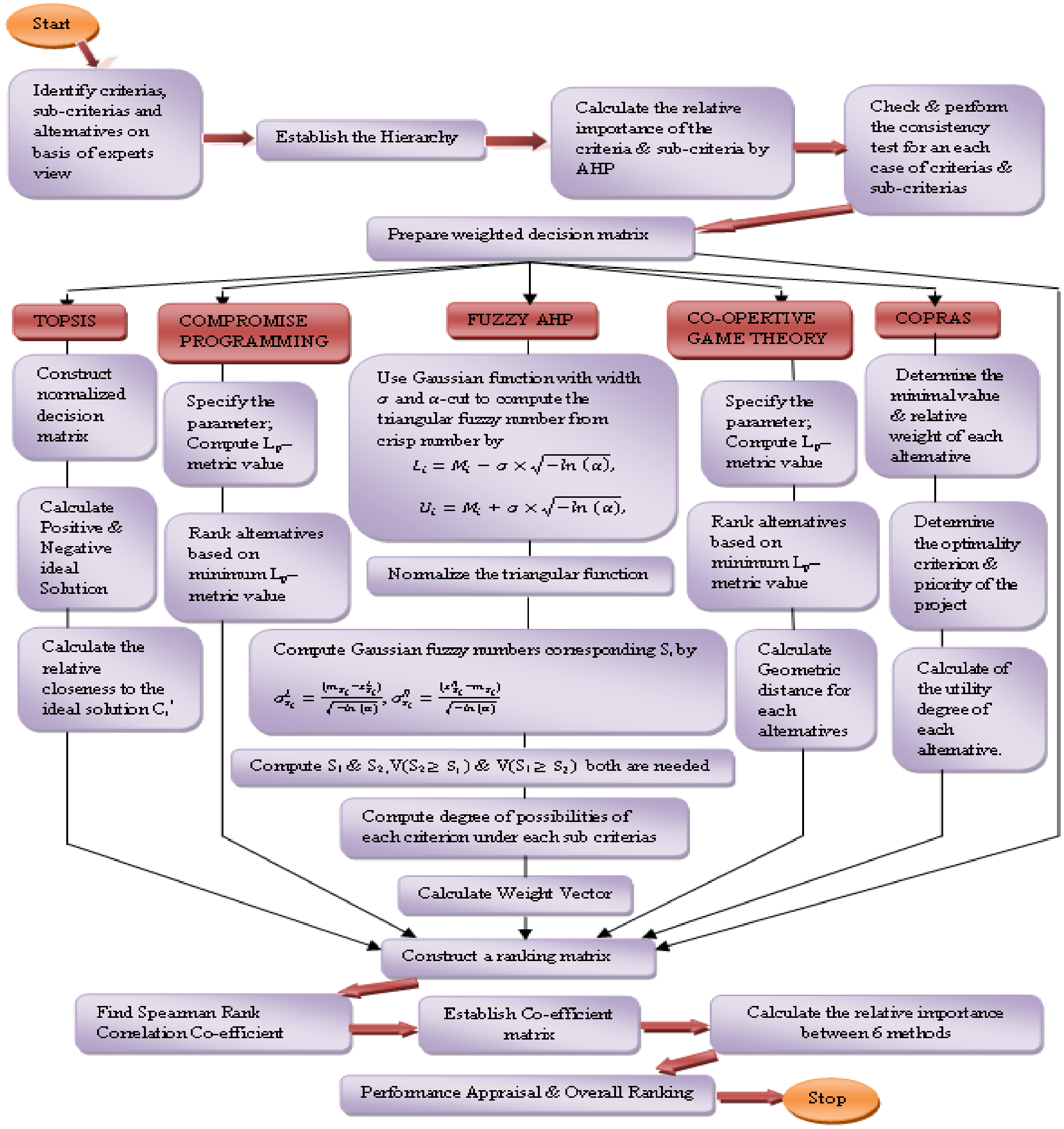

Figure II. Proposed Methodology.

Table III. Attributes weight by AHP and ranking.

Weight	0.1878	0.1245	0.0849	0.1579	0.105	0.0509	0.0378	0.028	0.047	0.0588	0.041	0.0488	0.0275	Globall Overall utility	Rank
Candidate	A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2		
a	0.1672	0.2139	0.2142	0.1021	0.1343	0.2212	0.1132	0.2049	0.2000	0.1670	0.2663	0.1236	0.1695	0.1686	3
b	0.1240	0.1605	0.0967	0.2661	0.1323	0.1705	0.2419	0.2814	0.1450	0.1678	0.2021	0.1667	0.3031	0.1746	2
c	0.1241	0.2002	0.1607	0.2256	0.2874	0.1710	0.3233	0.2157	0.2700	0.2779	0.1502	0.3027	0.1260	0.2081	1
d	0.2946	0.1208	0.0951	0.1028	0.0548	0.2280	0.1045	0.0957	0.0799	0.1639	0.0835	0.1236	0.0601	0.1432	6
e	0.1660	0.0904	0.3417	0.0779	0.1741	0.1294	0.1331	0.0734	0.2000	0.1019	0.1127	0.1628	0.1718	0.1484	5
f	0.1241	0.2142	0.0915	0.2256	0.2170	0.0798	0.0840	0.1290	0.1051	0.1215	0.1852	0.1206	0.1695	0.1572	4

Table IV. Ranking of candidates in Fuzzy AHP method

Weight	0.1878	0.1245	0.0849	0.1579	0.1046	0.0509	0.0378	0.0284	0.0474	0.0588	0.0407	0.0488	0.0275		
Candidate	A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	Globall Overall utility	Rank
a	0.1865	0.2006	0.1983	0.0604	0.1521	0.2726	0.1210	0.2412	0.2090	0.1430	0.3070	0.1200	0.1474	0.1683	3
b	0.0622	0.1666	0.0587	0.4247	0.1224	0.1551	0.2673	0.3338	0.1666	0.1781	0.1790	0.1833	0.2213	0.1854	2
c	0.0623	0.2741	0.1417	0.2000	0.2984	0.2692	0.3748	0.2598	0.2742	0.3554	0.1241	0.3034	0.0526	0.2111	1
d	0.3906	0.0617	0.0896	0.0894	0.0065	0.1968	0.0968	0.0310	0.0487	0.1931	0.0267	0.1200	0.1571	0.1429	5
e	0.2361	0.0277	0.4815	0.0255	0.1800	0.0975	0.1139	0.0083	0.2090	0.0450	0.0901	0.1641	0.2742	0.1528	4
f	0.0623	0.2693	0.0303	0.2000	0.2408	0.0088	0.0262	0.1259	0.0924	0.0854	0.2731	0.1092	0.1474	0.1395	6

The input of TOPSIS is the weighted normalized matrix which is obtained from AHP (Table III). Calculate the relative closeness to the ideal solution, rank the alternatives according to ideal solution values in descending order in the following Table V.

Table V. Ranking of candidates in TOPSIS method.

Candidate	D_a^+	D_a^-	C_a	Rank
a	0.0965	0.0592	0.3802	5
b	0.0990	0.0779	0.4403	2
c	0.0840	0.0946	0.5296	1
d	0.1052	0.0774	0.4240	4
e	0.1061	0.0589	0.3572	6
f	0.1006	0.0750	0.4271	3

In COPRAS, Calculate weighted normalized decision matrix using the Table III. The influence of maximizing and minimizing criteria on the evaluation result is considered separately. This method presented here, uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree which is shown below in Table VI.

Table VI. Ranking of candidates in COPRAS method.

Candidate	S_{+j}	S_{-j}	$1/S_{-j}$	Z_j	Rank
a	0.1628	0.0058	171.8862	0.1658	3
b	0.1666	0.0080	125.1193	0.1688	2
c	0.1946	0.0061	163.2713	0.1975	1
d	0.1405	0.0027	367.9996	0.1471	6
e	0.1463	0.0021	480.0431	0.1549	5
f	0.1535	0.0037	272.8875	0.1584	4

In Compromise Programming specify the parameter; compute L_p–metric value from Table III. Rank alternatives based on minimum L_p –metric value which is presented in Table VII.

Table VII. Ranking of candidates in Compromise Programming method

Candidate	A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	Sum(P=1)	Rank
a	0.1402	0.0002	0.0433	0.1376	0.0689	0.0023	0.0332	0.0105	0.0175	0.0371	0	0.048	0.0151	0.5538	3
b	0.1878	0.054	0.0831	0	0.0697	0.0197	0.0129	0	0.0312	0.0368	0.0143	0.0365	0	0.546	2
c	0.1877	0.0141	0.0614	0.0339	0	0.0196	0	0.009	0	0	0.0259	0	0.02	0.3715	1
d	0	0.094	0.0837	0.137	0.1046	0	0.0346	0.0254	0.0474	0.0381	0.0407	0.048	0.0275	0.6808	5
e	0.1416	0.1245	0	0.1579	0.051	0.0339	0.0301	0.0284	0.0175	0.0588	0.0342	0.0375	0.0149	0.7301	6
f	0.1877	0	0.0849	0.0339	0.0317	0.0509	0.0378	0.0208	0.0411	0.0522	0.0181	0.0488	0.0151	0.623	4

Compute L_p–metric value from Table III using Co-operative Game Theory (CGT).The best suitable alternative is that which maximizes the distance from some reference point of minimum level rather than minimizing the distance to a goal which is shown in Table VIII.

Table VIII. Ranking of candidates in Co-operative Game Theory method

Candidates	A1	A2	A3	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	GeometrIc Mean	Rank
a	0.7727	0.9998	0.9413	0.7234	0.8938	0.9976	0.9235	0.9871	0.9785	0.9432	1.0000	0.8184	0.9783	0.315888015	1
b	0	0.9316	0.7196	1.0000	0.8914	0.9754	0.9844	1.0000	0.9505	0.9438	0.9826	0.9351	1.0000	0	3
c	0.2539	0.9852	0.8966	0.9625	1.0000	0.9756	1.0000	0.9893	1.0000	1.0000	0.9598	1.0000	0.9648	0.192929952	2
d	1.0000	0.8395	0.6972	0.7267	0	1.0000	0.9112	0.9386	0	0.9405	0	0.8184	0.0000	0	3
e	0.7685	0	1.0000	0	0.9325	0.9458	0.9419	0	0.9785	0	0.9281	0.9311	0.9788	0	3
f	0.2548	1.0000	0	0.9625	0.9630	0	0	0.9633	0.9085	0.8790	0.9764	0.0000	0.9783	0	3

Ranking of alternatives in different method are shown in Table IX.

Spearman Co-relation Co-efficient between the methods are shown in Table X.

Calculate the relative closeness between the methods. Finally determine the Ranking of the methods according to Spearman Correlation Coefficient are shown in the Table XI.

Table IX. Ranking of different methods.

Candidates	AHP	FUZZY AHP	TOPSIS	COPRAS	COMPROMISE PROGRAMMI	COOPERATIVE GAME THEORY
a	3	3	5	3	3	1
b	2	2	2	2	2	3
c	1	1	1	1	1	2
d	6	5	4	6	5	3
e	5	4	6	5	6	3
f	4	6	3	4	4	3

Table X. Correlation Coefficient Ranking by Spearman.

	AHP	FUZZY AHP	TOPSIS	COPRAS	COMPROMISE PROGRAMMING	COOPERATIVE GAME THEORY
AHP	1	0.8286	0.7143	1.0000	0.9429	0.4286
FUZZY AHP	0.8286	1	0.4857	0.8286	0.7714	0.4286
TOPSIS	0.7143	0.4857	1	0.7143	0.8286	0.2000
COPRAS	1.0000	0.8286	0.7143	1	0.9429	0.4286
COMPROMISE PROGRAM	0.9429	0.7714	0.8286	0.9429	1	0.4286
COOPERATIVE GAME THEORY	0.4286	0.4286	0.2000	0.4286	0.4286	1

Table XI. Relative Closeness between the methods.

Spearman	AHP	FUZZY AHP	TOPSIS	COPRAS	COMPROMISE PROGRAMMING	COOPERATIVE GAME THEORY	Sum	No of considered elements	Avg	Rank
AHP		0.829	0.714	1.000	0.943	0.429	3.914	5	0.783	3
FUZZY AHP	0.829		0.486	0.829	0.771	0.429	3.343	5	0.669	4
TOPSIS	0.714	0.486		0.714	0.829	0.200	2.943	5	0.589	5
COPRAS	1.000	0.829	0.714		0.943	0.429	3.914	5	0.783	2
COMPROMISE	0.943	0.771	0.829	0.943		0.429	3.914	5	0.783	1
COOPERATIVE GAME	0.429	0.429	0.200	0.429	0.429		1.914	5	0.383	6

It is noted from Table IX that different techniques provide different ranking for the same set of problems which is the main drawback of MCDM methods. To overcome these, a group decision making method is implemented to get a single ranking structure.

After getting ultimate ranking of six methods according to Spearman Correlation Coefficient in Table XI**,** it is very clear that **Compromise Programming** is more suitable method to evaluate the proper ranking of teacher with respect to their overall performance as compared to rest of techniques.

V. CONCLUSIONS

The creation and perfection of teaching evaluation system is a very important part of teaching work in recent years. In this paper, a new scientific model is proposed to evaluate teachers' overall performance. It is a superior method that enables the attribute-based aggregation for heterogeneous group of experts.

Each method has some advantages and disadvantages that affect the results of rating.

A. Advantages

In this proposed model according to Hesham A and et.al. we introduce Gaussian Fuzzy Number instead of triangular fuzzy number to overcome the drawback of Chang's Extent Analysis.

This proposed work eradicates the main drawback of multi-criteria decision analysis that is different multi criteria methods present different ranking for the same problem with same multiple attributes and same multiple alternatives although same decision maker.

In this model Spearman correlation coefficient methods are used to find the relative closeness between the different MCDM methods and the result of this work shows that the new model is scientifically and mathematically error free and generate accurate outcome in every time.

In final ranking it can be concluded that six methods share a strong, marked, substantial and definite relationship between them respectively as established by Spearman Rank Correlation Method. From Table XI, the final values are slightly differ from each other. That's why, we can also utilize rest of 5 existing methods to evaluate the performance of teachers.

B. Disadvantages

The restrictions of the study are shown in the first stage of the methodology that is data collection. The accuracy and exactness of data collected may not be sent percent. Here the number of experts' opinions for ranking of the criterias/sub criterias, alternatives is very few. Though in such a study, no minimum number fixed, we feel that a sample of 50-70 would have been better.

The presented method concludes that there is no suspicion about the 4th, 5th & 6th positions taken by teacher *f*, teacher *d* and teacher *e* respectively but teacher *a*, teacher *b* and teacher *c* all are strong contenders for the best position. Teacher *a* and teacher *b*, in spite of having a very strong Academic Qualification, industry experience and Periodically arrange seminar and workshop are not chosen as the best choice as they are extensively weak in Knowledge of subject, Communication skill, Self development, Mental stress and Research & Project production than teacher *c*. In comparison to this, which although has comparatively not so strong Academic Qualification, industry experience and Periodically arrange seminar and workshop but are very strong in depth of Knowledge, Communication skill, Self development, Mental stress and Research & Project production which are more essential criterias in an educational institution than others. Hence, teacher *c* is the best choice for his/her performance in an educational institution.

Finally this article introduces an approach that integrates AHP with Fuzzy AHP, TOPSIS, COPRAS, Compromise Programming and Cooperative Game Theory algorithm to sustain teachers' performance evaluation decisions.

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