Teacher's Performance Appraisal System Using Fuzzy Logic- A Case Study

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Abstract— Assessment of faculty performance is a significant element in enhancing the excellence of the work and improves their incentive to execute well. It also presents a basis for promotion and enhancing of an educational organization. Moreover teaching faculty are the most precious and active assets of an educational organization. This article presents a case study of a performance appraisal system, which deals the faculty's qualitative actions in fuzzy parameters to evaluate their performance in an Institute. The method constitutes of collection of fuzzy appraisals from immediate supervisors/in-charges, then transforms the linguistic appraisals into fuzzy numbers and calculates a performance evaluation score of the faculty. This case study promotes understanding, further feasible modifications and usage of the fuzzy performance appraisal system in reputed Educational organizations which will surely satisfy the actual purpose of faculty self appraisal with complete, accurate and unbiased information.

Keywords— *Faculty Evaluation, Fuzzy logic, Performance Appraisal.*

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I. INTRODUCTION

Fuzzy logic is a powerful problem solving methodology that capture the way humans represent and reason with the real-world knowledge in the face of uncertainty. Uncertainty arises due to generality, vagueness, ambiguity, chance, or incomplete knowledge. Fuzzy logic provides a simple way to draw definite conclusions from vague, ambiguous or imprecise information and approach to control problems mimics how a person would make decisions, much faster only. It resembles human decision making with its ability to work from approximate data and find precise solutions.

Performance appraisal system is an vital feature in enhancing the worth of the effort, motivates staff to make every effort in the growth of themselves and the organization. Regular review of faculty performance appraisal in an institute helps Director of the organization to recognize its strengths and weaknesses. Performance appraisal system aims to recognize the present position of their employee. The process includes collection of basic data, and conversion into a number called performance score, which decides the faculty's input to appraise individual input with regard to the institute's goals. It is essential to have a perfect unprejudiced faculty appraisal system.

To make a decision on the performance level of a lecturer, the characters like enthusiasm, pro activeness, moral values, behavior, interpersonal skills, comprehensive levels, skills to achieve a goal, target achieving attitude, time management, contribution to team targets, continuous development in knowledge, participation in training programs, innovative thinking, and problem solving techniques. As these factors are fuzzy in nature a fuzzy performance appraisal method is more suitable.

Performance appraisal system relates to the results of a college. Performance expected from a faculty of a super market is different from the performance of a scientist in science research lab. In an examination performance of a student expected in a written test varies from performance expected in a project presentation.

Therefore, even within an institute, performance expected from faculty is not the same from all. It varies according to the nature of work, designation and sector of college. In a University, faculties of college are people who directly contact, educate and contribute to student's knowledge. Thus, performance of a faculty is vital both for students and college, and must be measured for positive reinforcement to faculty knowledge and understanding. Fuzzy concept gives a wide chance to measure, evaluate, and analyze these fuzzy factors.

Zadeh, in his pioneering paper introduced the notion of Fuzzy Subset of a set X as a function μ from X to the closed interval [0,1] of real numbers. The function μ is called the membership function which assigns to each member x of X its membership value, μ(x) in [0, 1].

Arbaiy and Suradi [1] studied the hierarchical fuzzy inference approach which has the ranking for staff performance as the output and concluded that reasoning based on fuzzy models will provide an alternative way in handling various kinds of imprecise data, which often reflected in the way people think and make judgments.

Pavani, Gangadhar and Kajal [2] explained the comparison of two different membership function and getting more or less similar, So as to achieve the shape of membership function, which is not playing much role to evaluate the performance in positive or negative direction.

Hota, Pavani and Gangadhar [3] used *fuzzy logic based MCDM method: fuzzy AHP to decide the ranking of teacher for further decision making*.

Nisha and Srinivas [4] Performance facilitated the performance appraisal process through Fuzzy evaluation technique as the use of fuzzy logic allowed reviewers to express themselves linguistically and to draw definite conclusions from vague, ambiguous or imprecise information. They discussed the parameters that effects the performance evaluation along with their fuzzy membership functions as well as system architecture for Fuzzy methodology based performance appraisal.

Bhosale and Kulkarni [5] attempted to highlight the role of Fuzzy techniques in measuring performance of teaching staff for appraisal.

Shaout and Trivedi [6] considered 'rating' as the most important and crucial step which involves human judgment and perception which inherently leads to the vagueness in taking decision or Fuzzy decisions. They proposed a stage-wise fuzzy reasoning model for performance rating.

Bhosale and Kamath [7] developed a fuzzy inference system(FIS) for teaching staff performance appraisal using Matlab. The research formulates the mappings from factors affecting performance to the incentives.

Ameet and Ladhake [8] used Multi-user Feedback support system or 360^0 Feedback with four components that include self-appraisal, superior's appraisal, subordinate's appraisal student's appraisal and peer's appraisal, to collect the data on the performance of an individual from a number of stakeholders and used for improving performance.

Nisha and Priti [9] discussed the parameters that effect the performance evaluation and gave design of employee evaluation interface. The evaluations are expressed using fuzzy scales. Weight matrices are designed for each evaluation parameter and final evaluation is computed as weighted average of fuzzy evaluations.

II. METHODOLOGY

In this method, fuzzy linguistic terms is used to observe the faculty's positive and negative aspects in comparison to the Institutes mission and vision. Suppose that there are 10categories C*i, i* = 1, 2, 3, . . .,*10* in a performance appraisal form and it evaluates 5 independent objectives O*j* , *j* = 1, 2, 3, 4, 5. *Let* S_k denote the k^{th} supervisor and *k* = 1, 2, 3,*4, 5 who* rate each faculty and F*r* denote r^{th} faculty and r denotes number of faculty's; *r* = 1, 2, 3 . . . *40* in a department of an institute. A supervisor is not forced to fix terms (crisp) and they are structured in their objectives. $\tilde{a}_{i,j}^{r,k}$ denotes fuzzy assessment of a faculty F*r*, assessed by a supervisor S_k, on Organization Mission Vision (OMV) j, from category i of an appraisal form. Different types of conversion scales of a linguistic term into a fuzzy number is considered.

III. IMPLEMENTATION PROCEDURE

The Director/Principal of an organization defines OMV in initial stage. Then Head of the Department (HOD), Asst. Head and other in-charges derive goals of each department of the institute to reach OMV. They divide responsibilities and targets among the faculty based on their skills and qualifications. In the initial stages of the semester/ academic year, the HOD/Asst. HOD communicates to the faculty about the desired outcomes and performance standards expected. So each faculty's target in a college directly or indirectly links to Organization Mission Vision (OMV). This gives the outline of a Fuzzy Performance Appraisal System (FPAS).

Based on the outline, each faculty report their achievements, tasks assigned, class work handled with innovative methodologies, remedial/makeup classes, results and other mile stones during the last academic year. Every supervisor assesses all his subordinates and reports at regular intervals to the higher authorities. Supervisor uses Fuzzy Performance Appraisal System Score to find a rank of each faculty and reports to Director/Principal and in turn support the top level management to identify strength and weakness of every faculty with detailed report map to OMV. This method consists of three phases. In first phase a HOD collects appraisals from i) Asst. HOD (supervisor 1), ii) In-charge (supervisor 2), iii) self appraisal by the faculty himself (supervisor 3), iv) subject expert (supervisor 4), and v) faculty from outside department as per the choice of the faculty (supervisor 5). Appraisal form contains necessary data regarding past academic details; for which the supervisors and faculty them self give their feedback. They express their satisfaction level, and evaluate performance expected from them. Fuzzy Performance Appraisal System Score gives the supervisors to express their satisfaction level in verbal terms.

In second phase, the HOD converts all linguistic terms under an objective with an apt conversion scale into a fuzzy number.

Third phase converts the fuzzy numbers into fuzzy weights or fuzzy appraisals of a faculty unfolding their targets, skills, proficiency to achieve OMV. The HOD's information from self appraisal forms of each faculty in term of fuzzy numbers in the form of a matrix is given in (1). Degree for each linguistic term for an objective is taken as one.

$$\tilde{E}_{i,j}^{r,k} = \begin{pmatrix} a_{1,1}^{1,1} & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & a_{10,5}^{40,5} \end{pmatrix} \qquad (1)$$

The outline of an appraisal form for a faculty at same cadre is given by matrix (2). This outline change with respect to

cadre of a faculty within a department and represent the expected performance of a faculty in a year.

$$P=\begin{pmatrix} p_{1,1} & \cdots & p_{1,5} \\ \vdots & \ddots & \vdots \\ p_{10,1} & \cdots & p_{10,5} \end{pmatrix} \quad (2)$$

With $\sum_{i=1}^{10}\sum_{j=1}^{5} p_{ij} = 100$ (3)

Now the HOD derives weighted fuzzy appraisals of a faculty by each administrator or experts given in the following matrix.

$$\widetilde{W}_{i,j}^{r,k}=\begin{pmatrix} a_{1,1}^{1,1}\times p_{1,1}=w_{1,1}^{1,1} & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & a_{10,5}^{40,5}\times p_{10,5}=w_{10,5}^{40,5} \end{pmatrix} \quad (4)$$

The Matrix (5) represents each faculty's total fuzzy appraisals on their achievement on objective 'i'. Objectives of an appraisal form relates directly or indirectly to OMV. From Matrix (5) the administrator understands the significance of the faculty's contribution to OMV.

$$\widetilde{M}_{i,j}^{r,k}=\begin{pmatrix} b_j=\sum_{i=1}^{10} w_{i,1}^{1,1} & \\ & b_j=\sum_{i=1}^{10} w_{i,5}^{40,5} \end{pmatrix} \quad (5)$$

The average fuzzy score across supervisors are given in matrix (6).

$$\widetilde{M}_{j}^{r}=\begin{pmatrix} C_j=\frac{\sum_{k=1}^{5} m_{i,j}}{5} \end{pmatrix} \quad (6)$$

To prepare incentives, promotions, the HOD computes fuzzy appraisal of each faculty by using Equation (7), which provides sufficient information to the director/principal of the Institute.

$$\widetilde{w}_r = \frac{\sum_{j=1}^{m} \tilde{c}_j^r}{m} \quad \frac{\sum_{j=1}^{m} C_j}{m} \quad (7)$$

IV. CASE STUDY

Suppose AITAM College expects its faculty to complete four objectives of their Organizational Mission and Vision (OMV). Let the total number of faculty be 10 say, F_1, F_2, F_3,. . .,F_{10} of the cadre Asst. Professor of a department relates to these four objectives during the academic year. Structure of appraisal form suits to department objective, including qualitative and quantitative measurements are O1, O2, O3 and O4, which are assumed to be as O1-syllabus coverage, O2-Results, O3-Course files, O4- Research and development. Appraisal forms contain four Categories C1-time spent, C2-knowledge, C3-methodology and C4-standards, with weights 10, 20, 30 and 40. OMV links to objectives O1, O2, O3 and O4 with weights 28, 22, 25 and 25. Object oriented weight structure of basic data of the category and OMV weight structure expected from a faculty is shown in following outline design 'P'.

TABLE 1: OUTLINE DESIGN 'P' OF APPRAISAL FORM

P	***O1***	***O2***	***O3***	***O4***	**Weights**
C1	2	3	4	1	10
C2	6	2	*8*	4	20
C3	8	5	*7*	10	30
C4	*12*	*12*	6	10	40
Weights	28	22	25	25	100

The linguistic terms used are Very Low (VL), Low (L), Medium(M), Medium to High(MH), High(H) and Very High (VH) for O1. According to standard conversions scales [28, 50, 117–121], Scale-5 is suitable for O1. O2 uses terms Low(L), Medium(M), High(H). Scale-2 is suitable for O2 and O3. O4 uses Excellent (E) and Not applicable (N) in addition to above linguistic terms. So scale-8 fits into O4. The fuzzy linguistic assessment of 10 faculty by one supervisor is given in Tables from 2 - 11.

TABLE 2: EXPERTS FEEDBACK FOR FACULTY-1

F_1	***O1***	***O2***	***O3***	***O4***
C1	*M*	*L*	*L*	*ML*
C2	*M*	*L*	*L*	*MH*
C3	*VL*	*M*	*L*	*E*
C4	*L*	*L*	*L*	*N*

TABLE 3: EXPERTS FEEDBACK FOR FACULTY -2

F_2	***O1***	***O2***	***O3***	***O4***
C1	*M*	*L*	*M*	*N*
C2	*VL*	*H*	*L*	*ML*
C3	*MH*	*H*	*H*	*VH*
C4	*VL*	*H*	*L*	*E*

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TABLE 4: EXPERTS FEEDBACK FOR FACULTY -3

F_3	***O*1**	***O*2**	***O*3**	***O*4**
***C*1**	*L*	*H*	*H*	*ML*
***C*2**	*VL*	*H*	*M*	*H*
***C*3**	*L*	*H*	*H*	*VL*
***C*4**	*L*	*L*	*L*	*E*

TABLE 5: EXPERTS FEEDBACK FOR FACULTY -4

F_4	***O*1**	***O*2**	***O*3**	***O*4**
***C*1**	*VH*	*H*	*M*	*E*
***C*2**	*H*	*H*	*H*	*VH*
***C*3**	*M*	*H*	*M*	*E*
***C*4**	*VL*	*L*	*H*	*N*

TABLE 6: EXPERTS FEEDBACK FOR FACULTY FACULTY -5

F_5	*O*1	*O*2	*O*3	*O*4
*C*1	*VH*	*H*	*M*	*VH*
*C*2	*H*	*H*	*H*	*VH*
*C*3	*M*	*M*	*M*	*M*
*C*4	*VL*	*H*	*H*	*VL*

TABLE 7: EXPERTS FEEDBACK FOR FACULTY -6

F_6	*O*1	*O*2	*O*3	*O*4
*C*1	*VL*	*H*	*H*	*VL*
*C*2	*L*	*M*	*M*	*N*
*C*3	*VH*	*L*	*L*	*ML*
*C*4	*VH*	*H*	*H*	*VH*

TABLE 8: EXPERTS FEEDBACK FOR FACULTY -7

F_7	*O*1	*O*2	*O*3	*O*4
*C*1	*VH*	*L*	*L*	*H*
*C*2	*H*	*H*	*H*	*VL*
*C*3	*VL*	*H*	*M*	*E*
*C*4	*VL*	*H*	*H*	*MH*

TABLE 9: EXPERTS FEEDBACK FOR FACULTY -8

F_8	*O*1	*O*2	*O*3	*O*4
*C*1	*VH*	*H*	*L*	*L*
*C*2	*H*	*L*	*L*	*MH*
*C*3	*M*	*L*	*H*	*ML*
*C*4	*VL*	*H*	*H*	*VH*

TABLE 10: EXPERTS FEEDBACK FOR FACULTY -9

F_9	*O*1	*O*2	*O*3	*O*4
*C*1	*VH*	*M*	*M*	*N*
*C*2	*H*	*L*	*L*	*MH*
*C*3	*M*	*L*	*M*	*H*
*C*4	*VL*	*H*	*L*	*ML*

TABLE 11: EXPERTS FEEDBACK FOR FACULTY -10

F_{10}	*O*1	*O*2	*O*3	*O*4
*C*1	*VH*	*M*	*H*	*H*
*C*2	*H*	*H*	*L*	*MH*
*C*3	*M*	*L*	*L*	*H*
*C*4	*VL*	*M*	*M*	*E*

By converting the linguistic terms into fuzzy number by using conversions scales, we get

TABLE 12: FUZZY NUMBERS CONVERSION FOR FACULTY-1

F_1	*O*1	*O*2	*O*3	*O*4
*C*1	(0.4,0.5,0.5,0.6)	(0,0,0.2,0.4)	(0,0,0.2,0.4)	(0.3,0.4,0.4,0.5)
*C*2	(0.4,0.5,0.5,0.6)	(0,0,0.2,0.4)	(0,0,0.2,0.4)	(0.5,0.6,0.6,0.7)
*C*3	(0,0,0.1,0,2)	(0.2,0.5,0.5,0.8)	(0.2,0.5,0.5,0.8)	(0.9,1,1,1)
*C*4	(0.1,0.2,0.2,0.3)	(0,0,0.2,0.4)	(0,0,0.2,0.4)	(0,0,0,0.1)

TABLE 13: WEIGHTED ASSESSMENT OF FACULTY -1

F_1	*O*1	*O*2	*O*3	*O*4
*C*1	(0.8, 1, 1, 1.2)	(0, 0,0.6,1.2)	(0,0,0.8,1.6)	(0.3,0.4,0.4,0.5)
*C*2	(2.4,3,3,3.6)	(0,0,0.4,0.8)	(0,0,1.6,3.2)	(2,2.4,2.4,2.8)
*C*3	(0,0,0.8,1.6)	(1,2.5,2.5,4)	(0,0,1.4,2.8)	(9,10,10,10)
*C*4	(1.2,2.4,2.4,3.6)	(0,0 ,2.4,4.8)	(0,0,1.2,2.4)	(0,0,0,1)
Total	(4.4,6.4,7.2,10)	(1,2.5,5.9,10.8)	(0,0,5,10)	(11.3,12.8, 12.8,14.3)

TABLE 14: FACULTY -1 CONTRIBUTION TO OBJECTIVES

Objective	Fuzzy Evaluation Score	Expected
*O*1	(4.4,6.4,7.2,10)	28
*O*2	(1,2.5,5.9,10.8)	22
*O*3	(0,0,5,10)	25
*O*4	(11.3,12.8,12.8,14.3)	25

The fuzzy weights of faculty's are given in Table 15, which illustrates fuzzy performance appraisal of the faculty. Computation of appraisal from Table 14 for faculty -1 is as follows:

$$\frac{4.4}{28}+\frac{1}{22}+\frac{0}{25}+\frac{11.3}{25}=0.1636$$

$$\frac{6.4}{28}+\frac{2.5}{22}+\frac{0}{25}+\frac{12.8}{25}=0.214$$

$$\frac{7.2}{28}+\frac{5.9}{22}+\frac{5}{25}+\frac{12.8}{25}=0.309$$

$$\frac{10}{28}+\frac{10.8}{22}+\frac{10}{25}+\frac{14.3}{25}=0.455$$

TABLE15: FINAL FUZZY WEIGHTS, SCORE VALUE AND GRADING OF FACULTY'S BY ONE SUPERVISOR

Faculty	**fuzzy weights *Wi***	**Score value**	**Rank**
F_1	(0.164,0.214, 0.309, 0.455)	0.784	10
F2	(0.404,0.507, 0.622, 0.709)	1.518	4
F3	(0.283, 0.4, 0.49,0.597)	1.198	9
F4	(0.386,0.499,0.589,0.687)	1.462	5
F5	(0.384,0.55,0.629,0.737)	1.549	3
F_6	(0.441,0.57,0.669,0.758)	1.648	1
F7	(0.424,0.55, 0.655, 0.73)	1.594	2
F8	(0.368, 0.474, 0.575, 0.682)	1.422	6
F9	(0.291, 0.41, 0.493, 0.639)	1.245	8
F10	(0.329, 0.461, 0.527, 0.687)	1.362	7

To prepare incentives and promotions, the Head of the department computes fuzzy appraisal of each faculty by using the Equation (7), which helps director/principal to get an information about overall importance of a faculty to the Institute. In the above procedure, scale of assessment for skills is determined by variation of faculty's performance, but not defined by a supervisor. This reduces leniency or severity error in assessing faculty. Periodical appraisal and improvement in performance can be identified by Director and Principal for quick and timely decisions.

V. CONCLUSION

Fuzzy performance appraisal system is a enhanced method for assessing faculty's performance in a perfect manner. Here the supervisors and faculty themselves are supposed to appraise in linguistic terms. Performance distribution depends on individual faculty's achievements. Also performance appraisal score depends on more than one expert or self appraisal, which removes to large extent the bias error and improves the genuineness of the appraisal. A conventional method of calculating performance appraisal of a faculty is to find the single numerical value or rank to compare faculty's performance. If a particular vision or mission of an institute is found to be not up to the mark, it is difficult to identify the root cause for it. It is difficult to identify, which faculty underperformed in achieving the respective goal.

By this method, an institute can identify contributions of an r^{th} faculty to j^{th} objective. Various objectives of institute and faculty's contribution in each objective is observed and recorded in this FPASS, which is very useful information for the Director for future references and faculty's recruitment criteria.

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