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Soft Computing Model for Academic Performance of Teachers Using Fuzzy Logic

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Authors' contributions

This work was carried out in collaboration between all authors. OKC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. PGK and KCD managed the analyses of the study. KCD managed the literature searches. All authors read an approved the final manuscript.

Research Article

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ABSTRACT

Worldwide National policies on higher education are giving increasing importance to improve the quality of education on offer. Consequently, the evaluation of teachers' performance in teaching activity is especially relevant for the academic institutions. It helps to define efficient plans to guarantee quality of teachers and the teaching learning process. In this paper, a soft computing model for academic performance of the teachers in technical institutions based on teaching activity series of qualitative reports is presented. We have proposed a Fuzzy Expert System for evaluating teachers overall performance based on fuzzy logic techniques under "uncertain facts" in the decision making process. A suitable fuzzy inference mechanism and associated rule has been discussed. It introduces the principles behind fuzzy logic and illustrates how these principles could be applied by educators to evaluating teachers' performance. This model will help to write the Annual Confidential Reports of all the employees of an organization.

Keywords: Fuzzy sets; student feedback; teaching-learning process; teachers' academic performance; decision making.

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1. INTRODUCTION

In developing countries, higher education is seen as an essential means for creation and development of resources and for improving the life of people to whom it has to serve. A highly reliable and effective performance evaluation rule is essential in decision making environments. In real problems, evaluation techniques engage in handling cases like subjectivity, fuzziness and imprecise information. Application of the fuzzy set theory in evaluation systems can improve evaluation results (Turban, 2000). Several researchers have tried to solve this problem through the analytical hierarchy process (AHP) (Saaty, 1995), for example in personnel selection (Sonja, 2001) and shipping performance evaluation (Chou, 2001) whereby evaluation is done by aggregating all the fuzzy sets.

In the literature, various concepts focusing on the combination of fuzzy logic model with multi objective decision have been proposed that can assist in reducing errors in making a judgment (Liang, 1992). Fuzzy set membership enables the interpretations of linguistic variables in a very natural and plausible way to formulate and solve various problems. Although many evaluation methods for selecting or ranking have been suggested in the literature, as yet there is no method which can give a satisfactory solution to every situation. For this reason, a fuzzy evaluation method is proposed by combining the concepts introduced in (Biswas, 1995) and integrating them with a fuzzy rule that is derived automatically from input data.

The evaluation of teaching activity is especially important for universities, as guaranteeing the quality of their studies means assuring not only the professional skills of their teaching staff but also the quality of the teaching-learning. An evaluation of teaching activity must take into account all of the procedures carried out and evaluate their magnitude and quality and qualitatively (Aleamoni, 1999). The evaluation of teaching activity is understood to be an internal evaluation that the academic institutions carries out on its teaching staff to guarantee that teaching and other objectives of the institute are met.

The use of fuzzy logic approach for the evaluation of teachers' performance is newly introduced in academic institutes. However, it has reached a wide range of application areas in educational systems in addition to evaluation of student academic performance, including the evaluation of curriculum and that of the educators (Bai, 2006; Yadav et al., 2011).

In this paper we discuss the teachers' performance evaluation using Fuzzy Expert System at technical degree institutions of India. The proposed Fuzzy Expert System consider the various aspects of performance measures of teachers, like Students' Feedback, Results, Students attendance, teaching learning process, academic development of teacher and other performance like personal skills & abilities, etc. that have deep influence on the teachers' performance in technical institutions. Fuzzy model is designed to combine the knowledge and expertise of human experts with reasoning capabilities that will provide a great support to the head of the institution for decision-making in educational institutions.

2. OBJECTIVE

The objective of the study is to develop a soft computing model based on fuzzy logic to measure performance of teaching staff in technical institutions and a system of evaluation.

3. PROPOSED FUZZY MODEL FOR ACADEMIC PERFORMANCE EVALUATION

The evaluation of teaching activity can be defined as the systematic evaluation of teaching performance according to the professional role and contribution required to reach the objectives of the course in question taking into consideration the institutional context (Khan, 2011). Therefore, teaching activity implies the planning and management of teaching, the deployment of teaching methods, learning and evaluation activities, and finally the revision and improvement of the procedures carried out. A multicriteria analysis in ranking the quality of teaching using fuzzy rule is proposed by Mahmod Othman (2008).

To put the existing teachers on track, it is very necessary to evaluate their performance, may be in quarterly, in semester or annually, depends upon the resources in academic institutes possess. University or the institutions of higher education do not have uniform standard method or computerized solution for evaluating teachers' performance that covers all factors affecting directly or indirectly the quality of university or the institutes. Hence the fuzzy logic model is introduced to evaluate the teachers overall performance through his or her involvement in the various sub activity involved in the institute.

Elements: Based on the above discussion, Fuzzy Expert System considers the various elements of performance measures of teachers as shown in Table 1.

4. FUZZY EXPERT SYSTEM FOR ACADEMIC PERFORMANCE EVALUATION

Steps involved in the fuzzy Expert System are as follows:

4.1 Crisp Value (Data)

Teachers self-appraisal forms are filled in by respective teachers on the above elements with sub activity which then recommended by the Head of the Department and head of the institution with due verification. The Crisp data is tabulated from these forms (Table 12).

4.2 Fuzzification (Fuzzy Input Value)

The input variables (elements) are then divided into linguistic variables excellent, very good, good, average and poor. Membership functions are then formed assigning the proper range to respective linguistic variables. In this paper we have used the trapezoidal membership function for converting the crisp set into fuzzy set as in eqn. (1).

$$\mu_f(x) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b < x < c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & x > d \end{cases} \quad (1)$$

Table 1. Elements of the evaluation model

Element	Criteria	Teaching Quality (Content)
f_1	Students Feedback	
f_2	Result	
f_3	Students Attendance	
f_4	Teaching Learning Process	
	f_{41}	% Lectures Engaged
	f_{42}	Use of Advanced Teaching Tools
	f_{43}	Updating of Question Bank
	f_{44}	Continuous Evaluation (Sessional /Home Assignment/ Tutorial)
	f_{45}	% Syllabus Covered
f_5	Academic Development of Teacher	
	f_{51}	Ph.D. Submitted
	f_{52}	Passed M. Tech./M.E./M. Phil. or equivalent
	f_{53}	Research Papers Presented in National /International Conf.
	f_{54}	Research Papers Published in National /International Journal
	f_{55}	No. of Articles published in National or International Magazines/Periodicals.
f_6	Other Performance	
	f_{61}	Points given by Principal for extra contribution such as discipline/social etc.
	f_{62}	Points given by Head of the Department for extra efforts at departmental level.
	f_{63}	Membership of Professional Bodies. (UGC/ISTE/AICTE etc)
	f_{64}	Maintaining good record.
	f_{65}	Involvement in TG/Forum/CT/III/Alumni
	f_{66}	Worked as In charge and as a Member of committees like Examination / Admission / Maintenance / Warden / Any Portfolio Assigned by Principal
	f_{67}	Organizing Industry Visits/Tours/Seminars/Short Term Training Program

4.2.1 Students' feedback

Table 2. Students' feedback

S. N.	Year/Branch/ Section	Subject taught	Students feedback	Overall students feedback %
(1)	(2)	(3)	(4)	(5)
1	C_1	S_1	f_{11}	f_1 = Avg. of Col.4
2	C_2	S_2	f_{12}	
3	C_3	S_3	f_{13}	

Range for linguistic variables of the Students Feedback (f_1) is shown in Table 3.

Table 3. Students' feedback in terms of linguistic variables

Student Feedback	Poor	Average	Good	Very Good	Excellent
f_1 →	< 50	50-54.9	55-64.9	65-75	>75

Membership Function of the input variable Students Feedback (f_1) is shown in Fig. 1.

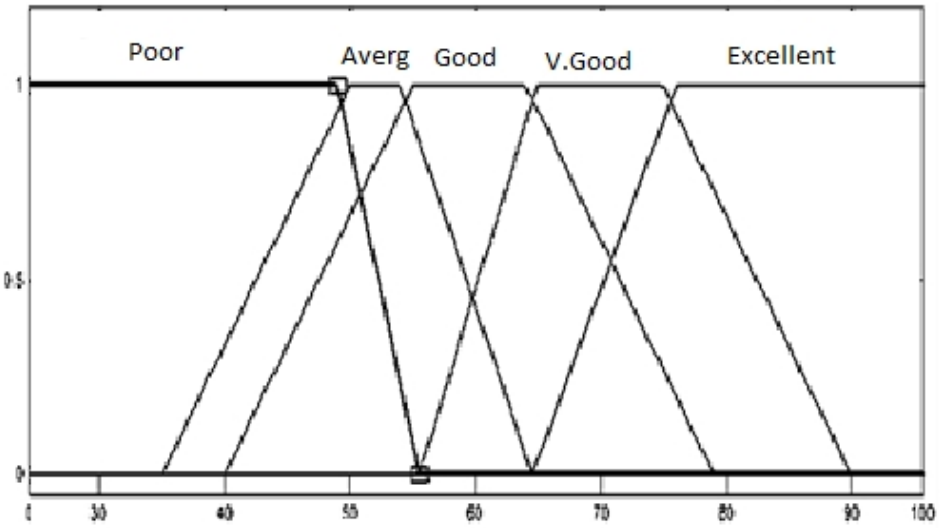

Fig. 1. Membership function of input variable f_1

4.2.2 Performance of result: (as a teacher)

Table 4. Performance of results

Sr. No.	Year/Branch/ Section	Subject Taught	Avg. Result of the Subject for Last 3 Yrs.	Performance of Results
(1)	(2)	(3)	(4)	(5)
1	C_1	S_1	f_{21}	f_2 = Avg. of Col.4
2	C_2	S_2	f_{22}	
3	C_3	S_3	f_{23}	

Range for linguistic variables of the Performance of Results (f_2) is shown in Table 5.

Table 5. Results in terms of linguistic variables

Performance of Results	Poor	Average	Good	Very Good	Excellent
f_2 →	< 50	50-59.9	60-69.9	70-79.9	>80

Membership Function of the input variable Results (f_2) is shown in Fig. 2.

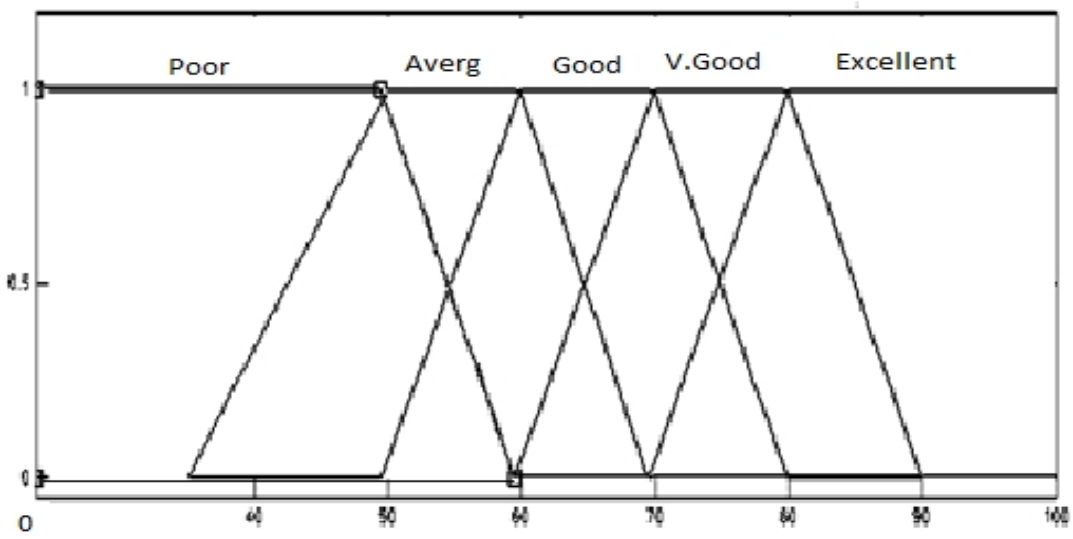

Fig. 2. Membership function of input variable f_2

4.2.3 Performance of students attendance: (as a teacher)

Table 6. Students' attendance

Sl. No.	Year/ Branch/ Section	Subject taught	Sum of students presents	No. of lectures actually engaged	Students on roll	Avg. Class wise attendance $\left(\frac{P_i}{N_i \times n_i} \times 100\right)$	Performance of students attendance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	C_1	S_1	P_1	N_1	n_1	f_{31}	f_3 = Avg. of Col.7
2	C_2	S_2	P_2	N_2	n_2	f_{32}	
3	C_3	S_3	P_3	N_3	n_3	f_{33}	

Range for linguistic variables of the Students Attendance (f_3) is shown in Table 7.

Table 7. Students' attendance in terms of linguistic variable

Performance of Students Attendance	Poor	Average	Good	Very Good	Excellent
f_3 →	< 75	75-79.9	80-84.9	85-90	>90

Membership Function of the input variable Students Attendance (f_3) is shown in Fig. 3.

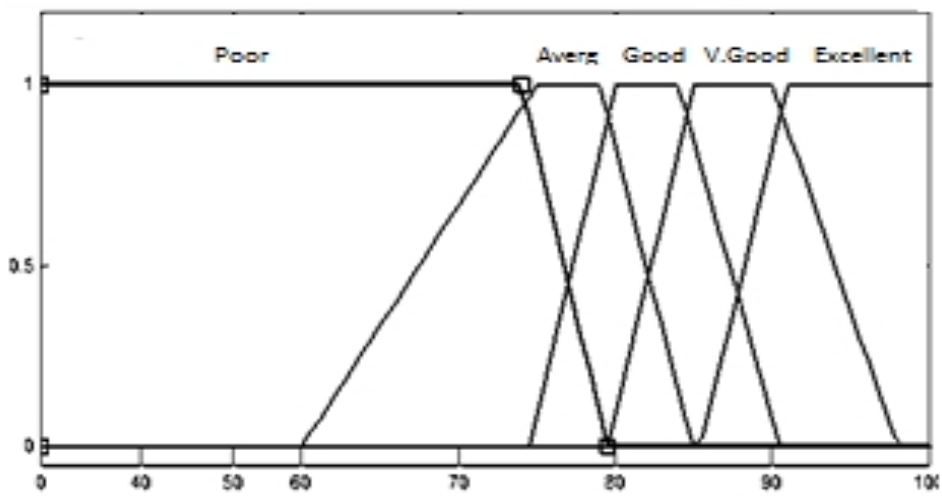

Fig. 3. Membership function of input variable f_3

4.2.4 Performance of teaching learning process (TLP): (as a teacher)

Performance of a teacher in Teaching Learning Process f_4 (Table 1) is given by equation (2).

$$f_4 = f_{41} + f_{42} + f_{43} + f_{44} + 2*f_{45} \quad (2)$$

Range for linguistic variables of the TLP (f_4) is shown in Table 8.

Table 8. TLP in terms of linguistic variable

Performance of teaching learning process	Poor	Average	Good	Very Good	Excellent
f_4 →	< 5	5 – 6	7 – 8	9 – 10	≥ 11

Membership Function of the input variable TLP (f_4) is shown in Fig. 4.

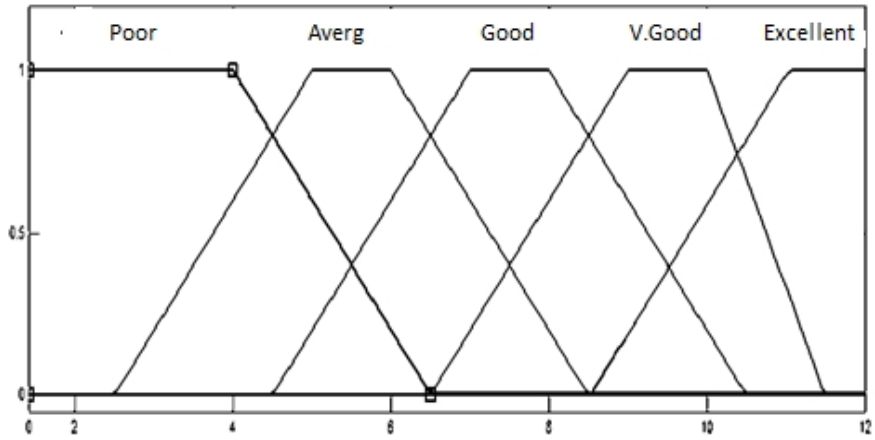

Fig.4. Membership function of input variable f_4

4.2.5 Academic development of teacher

Performance in Academic Development of Teacher f_5 (PADT) is given by equation 3 (Table 1).

$$f_5 = f_{51} + f_{52} + f_{53} + 2*f_{54} + (.5)*f_{45} \quad (3)$$

Range for linguistic variables of the PADT (f_5) is shown in Table 9.

Table 9. PADT in terms of linguistic variable

Performance in academic development of teacher	Poor	Average	Good	Very Good	Excellent
f_5 →	≤ 2	3 – 4	5 – 6	7 – 8	≥ 9

Membership Function of the input variable PADT (f_5) is shown in Fig. 5.

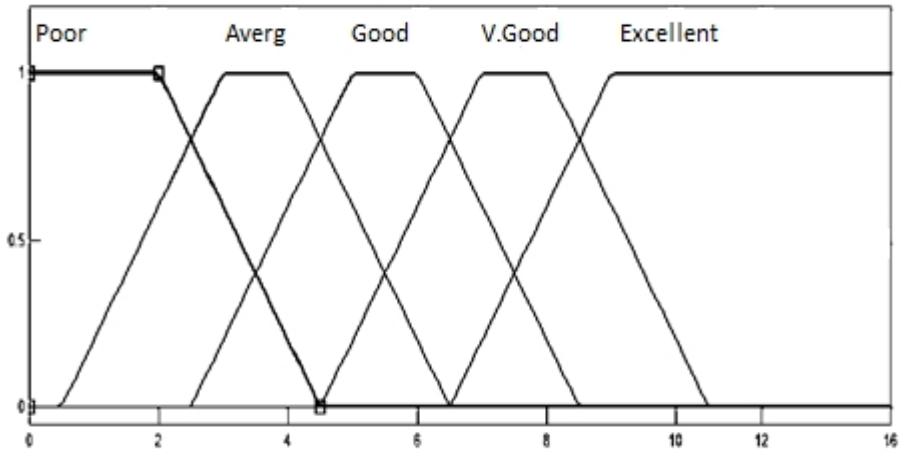

Fig. 5. Membership function of input variable f_5

4.2.6 Other performance

Other Performance of a teacher f_6 (Table 1), is measured by using equation (4).

$$f_6 = f_{61} + f_{62} + f_{63} + f_{64} + 2*f_{65} + 2*f_{66} + 2*f_{67} \quad (4)$$

Range for linguistic variables of other performance of a teacher (f_6) is shown in Table 10.

Table 10. Other performance in terms of linguistic variable

Other Performance	Poor	Average	Good	Very Good	Excellent
f_6 →	≤ 9	10 – 14	15 – 19	20 – 24	≥ 25

Membership Function of the input variable Other Performance of a teacher (f_6) is shown in Fig. 6.

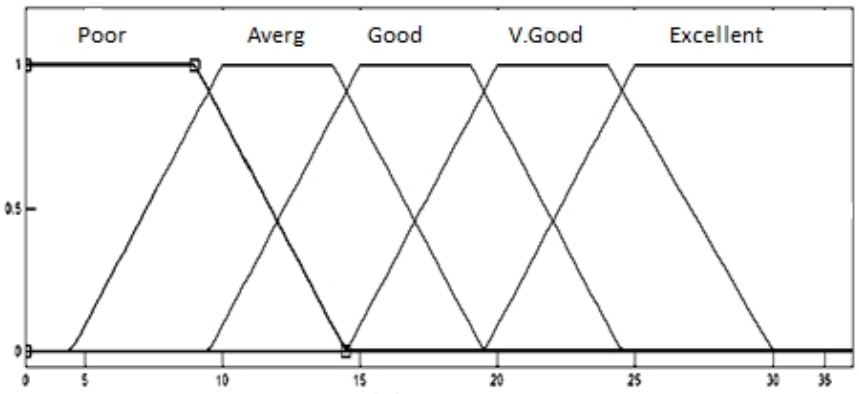

Fig. 6. Membership function of input variable f_6

4.3 Fuzzy Rule and Inference Mechanism

The rules determine input and output membership functions that will be used in inference process. These rules are linguistics and are entitled "IF-THEN" rules. From the discussion with the academic experts some rules are formulated from their practical and past experiences. In this study since the number of input variables are more, more number of rules are framed to justify important variables of the teaching learning process and the academic institute.

Table 11. Rules for the fuzzy system

S.N.	Input variable f_1	Input variable f_2	Input variable f_3	Input variable f_4	Input variable f_5	Input variable f_6	Output variable
1	Average	Poor	V. Good	Excellent	Excellent	Good	Average
2	Average	Poor	Good	Excellent	V. Good	Excellent	Average
3	Average	Poor	Good	V. Good	Good	Excellent	Average
4	Good	Good	Poor	V. Good	Good	Average	Average
5	Good	Good	Poor	V. Good	Average	Average	Average
6	Good	Average	Excellent	Average	V. Good	Poor	Average
7	Good	Average	Excellent	Average	Good	Poor	Average
8	Poor	Good	Poor	Average	Good	V. Good	Average
9	V. Good	V. Good	Good	Poor	Average	Good	Average
10	V. Good	V. Good	Average	Poor	Poor	Good	Average
11	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
12	Excellent	Excellent	Excellent	Excellent	V. Good	Excellent	Excellent
13	Excellent	Excellent	V. Good	Excellent	Excellent	Excellent	Excellent
14	Excellent	Excellent	Excellent	V. Good	Good	Excellent	Excellent
15	Excellent	Excellent	V. Good	Excellent	V. Good	Excellent	Excellent
16	Average	Poor	Good	V. Good	Average	V. Good	Good
17	Excellent	Excellent	V. Good	Good	Poor	V. Good	Good
18	Excellent	V. Good	Poor	V. Good	V. Good	Excellent	Good
19	Excellent	Excellent	Poor	Excellent	Poor	Excellent	Good
20	Excellent	Excellent	Average	Excellent	Poor	V. Good	Good
21	Excellent	Excellent	Good	Excellent	Poor	Good	Good

Table 11 continues…….

22	Excellent	Excellent	V. Good	Excellent	Poor	Average	Good
23	Excellent	Excellent	Poor	V. Good	Poor	Excellent	Good
24	Good	Average	Excellent	Good	Excellent	Average	Good
25	Poor	Excellent	Average	Good	Excellent	Excellent	Good
26	V. Good	V. Good	Good	Average	V. Good	V. Good	Good
27	V. Good	Excellent	Average	Excellent	Average	Excellent	Good
28	V. Good	Good	Average	Excellent	Excellent	Good	Good
29	V. Good	Excellent	Good	Excellent	Poor	V. Good	Good
30	V. Good	Excellent	V. Good	V. Good	Poor	Good	Good
31	V. Good	Excellent	Average	V. Good	Average	V. Good	Good
32	V. Good	Excellent	Excellent	Average	Average	Good	Good
33	V. Good	Excellent	Good	Excellent	Poor	V. Good	Good
34	V. Good	Excellent	Average	V. Good	Poor	Excellent	Good
35	Average	Average	V. Good	Poor	Average	Poor	Poor
36	Average	Average	V. Good	Poor	Poor	Poor	Poor
37	Good	Good	Poor	Good	Poor	Average	Poor
38	Excellent	Excellent	Poor	Excellent	Excellent	Excellent	V. Good
39	Excellent	Excellent	V. Good	V. Good	Average	Excellent	V. Good
40	Excellent	Excellent	Poor	V. Good	V. Good	Excellent	V. Good
41	Excellent	Excellent	Poor	V. Good	Excellent	Excellent	V. Good
42	Excellent	V. Good	V. Good	Good	Excellent	V. Good	V. Good
43	Excellent	Excellent	Average	V. Good	V. Good	Excellent	V. Good
44	Excellent	Excellent	Good	Excellent	Poor	Excellent	V. Good
45	Excellent	Excellent	Good	Excellent	V. Good	Excellent	V. Good
46	Excellent	Excellent	V. Good	Excellent	Poor	Excellent	V. Good
47	V. Good	V. Good	Average	V. Good	V. Good	Excellent	V. Good
48	V. Good	Excellent	Average	V. Good	Excellent	Excellent	V. Good
49	V. Good	Excellent	V. Good	Excellent	Excellent	Good	V. Good

4.4 Fuzzy Output (Overall Performance) and Defuzzification (Performances)

The output variable is the overall performance of the teacher, which has five linguistic variables. The degree of membership functions is given by equation (5).

$$\mu_F(x) = \underset{k}{Max}[\min[\mu_A(f_1), \mu_B(f_2), ...]], \quad k = 1,2,3,4,.....r \tag{5}$$

This expression determines an output membership function value for each active rule. When one rule is active, an AND operation is applied between inputs. The fuzzy linguistic variables of output variable are shown in Table 12.

Table 12. Teachers' Overall Performance in terms of Linguistic Variable

Teachers Overall Performance	Poor	Average	Good	Very Good	Excellent
P →	< 50	50 ≤ P <65	65≤ P <75	75≤ P <85	≥ 85

Membership Function of the output variable Overall Performance of a teacher (P) is shown in Fig. 7.

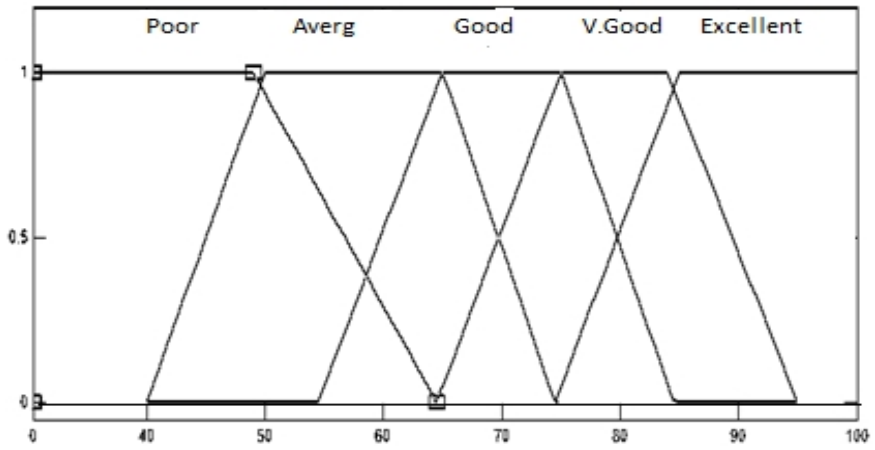

Fig. 7. Membership function of teachers overall performance

Rule viewer of the proposed fuzzy expert system for the evaluation of overall teacher's performance is shown in Fig. 8.

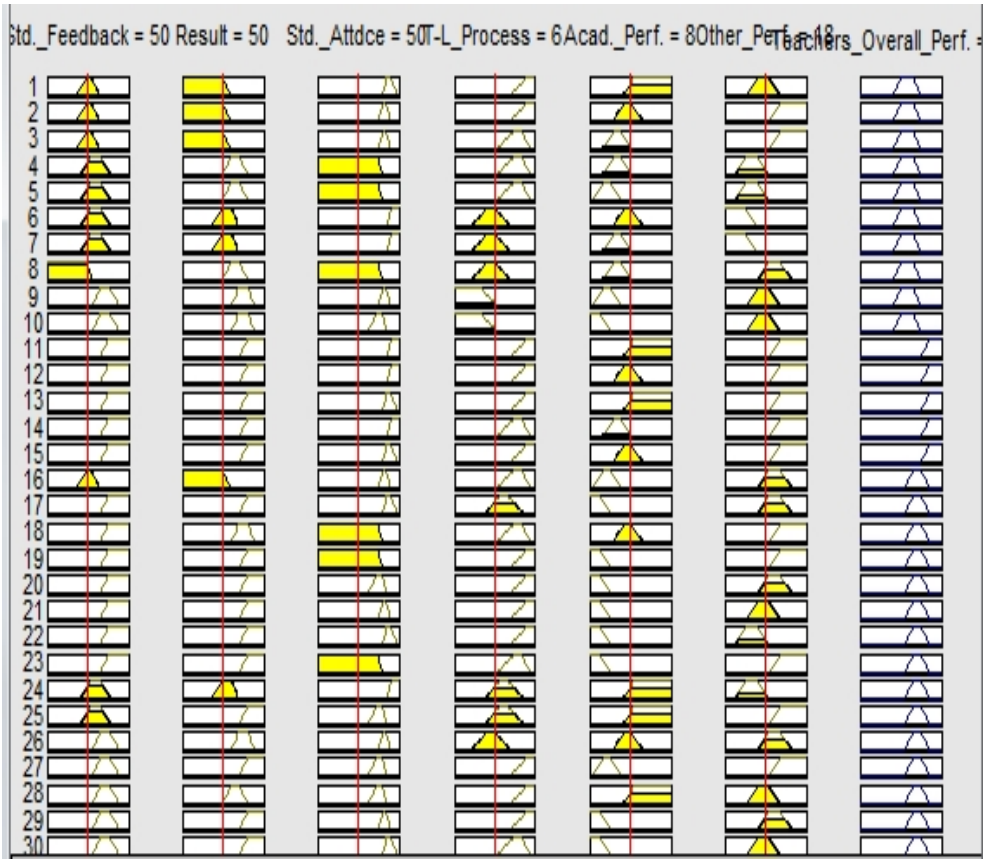

Fig. 8. Rule Viewer of fuzzy expert system

Surface viewer of proposed fizzy expert system for academic performance evaluation is shown in Fig. 9.

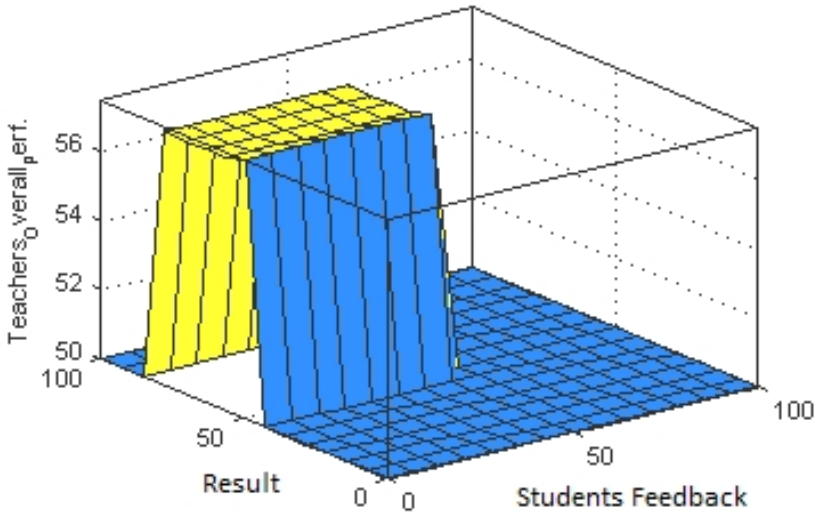

Fig. 9. Surface Viewer of Fuzzy Expert System

5. NUMERICAL RESULTS AND DISCUSSION

In order to test the above model by using the fuzzy expert system and the rules defined in the present study the data from one of the reputed engineering college have been used. From the input data the output variable overall performance of teacher is determined by direct method and also by using the fuzzy model developed in the study. Last two columns of Table 13 shows the values of teachers overall performance by direct method and Fuzzy Expert System respectively.

Table 13. Teachers overall performance (crisp and fuzzy)

Sl. No.	f_1	f_2	f_3	f_4	f_5	f_6	Output Value	
							Direct	Fuzzy
1	86	85	70	12	13	33	86	80
2	85	92	90	12	14	34	92	90
3	95	98	60	9	8	26	73	80
4	80	95	73	10	15	32	87	80
5	89	75	60	9	8	33	77	73
6	94	80	60	12	10	34	84	80
7	75	80	75	12	4	28	72	71
8	67	75	75	9	8	33	76	76
9	70	85	75	9	13	25	74	76
10	85	90	90	12	8	25	77	89
11	93	100	75	10	8	28	78	80
12	82	80	70	9	8	30	75	75
13	83	91	70	12	0	35	76	70
14	80	95	73	12	0	21	63	70
15	71	89	83	12	0	21	63	72
16	83	90	82	12	0	26	69	76

Table 13 continues……..

17	97	90	95	12	1	34	81	80
18	75	97	90	10	2	17	61	70
19	85	96	84	12	8	34	86	84
20	71	95	76	10	3	23	65	72
21	73	95	94	6	4	19	60	70
22	70	94	85	12	9	18	68	80
23	76	89	75	12	0	24	65	71
24	72	95	80	12	0	23	65	74
25	79	99	84	12	0	17	61	70
26	86	96	90	12	0	14	59	70
27	95	95	85	12	0	28	72	80
28	81	96	72	10	0	26	67	70
29	83	98	85	12	1	30	75	80
30	79	93	73	11	2	25	68	70
31	70	100	77	9	1	28	67	71

We observed the difference in the direct value and the values determined by using fuzzy model. This is due to the weightage given on some important parameters related to teaching learning process and overall development of the institute while framing the rules. So the overall performance of a teacher determined by fuzzy model is more realistic than the direct values.

6. CONCLUSIONS

Teachers' regular assessment is suggested to maintain quality in higher education. There is a vast potential of the applications of fuzzy expert system (FES) in teachers' assessment. Expert system technology using Fuzzy Logic is very interesting for quantitative and qualitative facts evaluation. In this paper a model of fuzzy expert system (FES) is proposed to evaluate teachers overall performance on the basis of various activities related to teaching learning process and other parameters that have been validated previously through subject experts. The qualitative variables are mapped into numeric results by implementing the fuzzy expert system (FES) model through various input examples and provided a basis to use the system for further decision making. In this way the teaching staff is encouraged to reflect on quality, adequacy, satisfaction, efficiency and innovation in teaching in the technical academic institutions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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