

# Fuzzy logic as a tool for evaluation of performance appraisal of faculty in higher education institutions

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**Abstract.** Performance appraisal of teaching faculty in higher education institutions is becoming increasingly challenging with the changing role of teachers in advancing knowledge to students necessitating use of advanced soft computing models. The conventional evaluation methods lack assigning weightage to individual criteria and rely on numerical values. Fuzzy logic advocated by Lotfi Zadeh (1965), used to measure faculty ability, competence and skills, which are actually fuzzy concepts that can be captured in fuzzy terms and fuzzy approach can be used to handle these imprecision and uncertainty information. Present study, we developed a fuzzy logic model using an algorithm in visual basics (VB) and implemented in Matlab, using Matlab Fuzzy logic toolbox, to predict the importance of each category in evaluating the faculty performance. Based on the calculated fuzzy values, the weighed values of each category were grouped for similarity and comparison. This provides a number of interactive tools that allows accessing many of the functions through a Graphic User Interface and also provides a 3-D visualization and fuzzy rule inference. It should not normally exceed 200 words.

## 1 Introduction

Higher education institutions often face the challenge of ensuring quality of teaching by their faculty. Administrators use performance appraisal as the method to evaluate performance of faculty. Performance appraisal reflects the effectiveness and efficiency of work done. It measures employee's actual performance relative to the standard performance so as to give feedback to the employee. It is a time consuming task but identifying the strengths and weaknesses of faculty can aid in providing opportunities for improvement and skills development. A highly reliable and effective performance evaluation rule is essential in decision making environments. Systematic appraisals can help the management in

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decision making in times of promotion, termination, hike in salary, etc. Performance appraisal by conventional methods employing objective and subjective measures can often lead to vagueness, uncertainty and imprecision.

The current performance appraisals tend to confuse people with systems, destroy teamwork, foster mediocrity, are limited to a short-term approach instead of adopting a long-term focus, decrease self-esteem, increase fear and reduce productivity and motivation (Roffe 1998). For this, Roffe describes the way in which a process of quality assessment was set in place in Wales, called Continuous Quality Improvement (CQI). This requires multiple feedback mechanisms, interlinking the different stakeholders such as peers, subordinates, superiors and students. He mentions the areas that need to be reviewed –

- Curriculum design, content and organization
- Teaching, learning and assessment
- Student progress and achievement
- Student support and guidance
- Learning resources
- Quality assurance and enhancement

In 1965, Lotfi Zadeh introduced fuzzy logic as means to model and handle uncertainty in natural language. Fuzzy logic describes the qualitative nature aspects of the object while conventional logic systems focus on their quantitative aspects.

Fuzzy logic is a powerful problem solving methodology that captures the way humans represent and reason with the real-world knowledge in the face of uncertainty arising due to vague, ambiguous, incomplete information. During such times, fuzzy logic provides a way to draw definite conclusions. The classical logic requires a deep understanding of a system, exact equations and precise numeric values, whereas fuzzy logic incorporates an alternative way of thinking allowing modelling complex systems using a higher level of abstraction originating from knowledge and experience. Most organizations use numerical values like 7 in 10 point scale or linguistic labels like Good, Very Good, Outstanding, etc., in their performance appraisal system. These scores are merely imprecise approximations as they are based on judgment making ability of the individual reviewing the information. Fuzzy logic allows reviewers to express themselves linguistically and to make assessments that are subjective in nature. Faculty performance involves parameters such as communication skills, attitudes, commitment, leadership qualities, innovativeness, responsibility, etc. which are very fuzzy and cannot be easily quantified.

Fuzzy Set Theory - an area under the umbrella of Soft Computing model is followed in the present work. The fuzzy values obtained aid in making clusters based on performance of faculty and helps the organization to exercise professional judgment in evaluating employees. In the study, soft computing model for academic performance evaluation of the teachers is presented.

## **2 Need for the study**

- Performance appraisals can play significant role in enhancing quality of education as well as motivating teachers to improve their performance, especially in higher education institutions. Several statistical methods were used for the faculty performance appraisal and the recent one is the Fuzzy logic advocated by Lotfi Zadeh [7].

- From fuzzy logic perspective, the performance of the appraisee involves the measurement of faculty ability, competence and skills, which helps to find imprecise and uncertain information.

### 3 Objectives of the study

- This study intends to develop a soft computing model for faculty performance evaluation using fuzzy logic reasoning.
- To test the usefulness of application of modern technology in performance evaluation in arriving at decisions under uncertainty.
- Review Of Literature: Research with regard to performance appraisal using soft computing methods such as fuzzy logic has been done in the recent times by several researchers across the globe. In the research by G. Meenakshi et al, they used Fuzzy based Multifactorial Evaluation Model for decision making in performance.

In the study by Abdur Rashid Khan et al on Application of expert system with fuzzy logic in teacher's performance evaluation they proposed a model of fuzzy expert system to evaluate performance of teachers based on various key performances attributes which previously have been validated by subject experts.

In the study by Bruno Trstenjak, Dzenana Donko on Teacher quality evaluation in Higher education institutions using fuzzy logic the authors proposed a system for the multi-criteria decision making problem for ranking the teacher's quality. For evaluating teacher's performance, the main emphasis is on analysis of the results of the student's survey and applying fuzzy logic to it by Fuzzy TOPSIS method.

In the study by G.A.Bhosale, R. S. Kamath on Fuzzy inference system for teaching staff performance appraisal fuzzy rule base is developed which is related to different categories in API of UGC. In the manual system user need to enter appropriate score for each category but here in Fuzzy Inference System membership function calculate the score based on logical reasoning.

In another study by Mahmod Othman, Ku Ruhana Ku-Mahamud, Azuraliza Abu Bakar Fuzzy evaluation method using fuzzy rule approach in multicriteria analysis by combination of quantitative and fuzzy methods.

In the study by Azizul Azhar Ramli and Nureize Arbaiy Hierarchical fuzzy rule-based model for teaching performance evaluation , the authors emphasized on the mapping of uncertainty data in performance measurement system which convert the data into fuzzy values that consist of labels and confidence value.

### 4 Methodology

The faculty performance is evaluated as per the Academic Performance Indicator (API) format prescribed by the University Grants Commission (UGC). According to API, the following categories are considered for faculty performance evaluation:

- Category I: Teaching, learning and evaluation related activities.
- Category II: Co-curricular, Extension, Professional Development related activities
- Category III: Research, Publications and Academic Contributions

Data was collected from faculty performance appraisal forms of JSS University, Mysore, India, and was used for the study with the consent of the university authorities. The value obtained for each category was as follows:

- Category – I varies from 0 to 15
- Category – II varies from 0 to 25
- Category – III varies from 0 to 150
- Output will be varying from 0 to 150

The scores for each category is computed in Matlab using fuzzy inference system. The Fuzzy Inference System (FIS) uses the following steps:

**Fuzzification:** The process of converting Academic Performance Indicators (API) scores into fuzzy inputs with the help of membership functions which is a curve, defines how each point in the input space is mapped to a membership value between 0 and 1.

**Fuzzy Outputs:** Inference engine then applies reasoning to compute fuzzy outputs done by using if-then rules which relate multiple input and output variables.

**Defuzzification:** The internal fuzzy output variables are converted into crisp values that can actually be used. Crisp output denotes overall performance of the employee. The Centroid calculation method is used for defuzzification.

**Rule-Base:** It is a collection of knowledge in the If-Then format from experts. It describes the relationship between input parameters and output. It is used to display how an output is dependent on any one or two of the inputs.

MATLAB is used for the application development taking into consideration all the parameters for faculty performance evaluation.

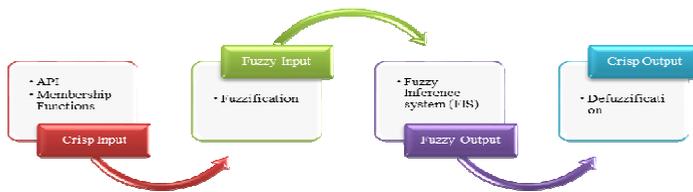


Fig. 1. Architecture of Fuzzy logic method

## 5 Results

The API scores of faculty for each category was calculated with respect to 10 for obtaining significance in the graphical representation. The fuzzy value was calculated taking into consideration the individual score and the highest score in the column for all categories. The statistical value was also calculated taking into consideration the individual score and the highest score in the column. The correlation between fuzzy value and statistical value was found to be 0.934088.

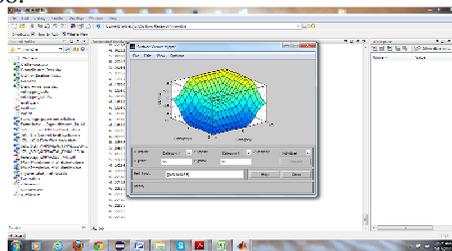


Fig. 2. Surface Viewer Tipper

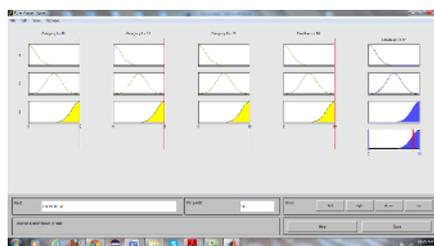


Fig. 3. Rule Viewer Tipper

Table 1. API scores of faculty with respect to 10 for Category I, II, III, Feedback and its associated Fuzzy and Statistical Values.

Sl.No.	Cat 1	Cat 2	Cat 3	Feedback	Fuzzy Value	Statistical Value
1	10	10	10	10	8.77	8.953946
2	7.043478261	6.8	1.142473	7.822667	4.39	5.183758
3	7.906086957	10	3.326613	8.389333	6.36	7.086115
4	9.239130435	10	9.811828	9.128	8.51	10
5	8.930434783	10	6.384409	8.990667	6.38	8.563887
6	6.086956522	4	0.268817	4.382667	3.79	3.33476
7	10	10	3.326613	7.454667	6.36	7.28785
8	9.565217391	10	6.989247	8.538667	6.66	8.390116
9	10	10	0.907258	8.806667	5.13	6.307425
10	10	10	0.840054	8.034667	5.1	6.070878
11	3	10	0.873656	8.601333	5.11	5.635736

Corr = 0.934088

Based on the fuzzy values faculty were grouped into clusters as follows:

Table 2. Clusters of faculty based on Fuzzy values and Statistical values.

Clusters	Fuzzy Value	Statistical Value
<5	2	1
>=5 and <6	3	2
>=6 and <7	4	2
>7	2	6

Clustering could be done more efficiently using fuzzy value than statistical value as depicted in the table. Fuzzy values are true values and hence measurement of performance of faculty across all categories can be assessed effectively and efficiently irrespective of cadre and designation.

## 6 Inference

- Teachers could be grouped for efficient team building using fuzzy. Dividing it by Max value in category 3 for conversion with respect to 10 will remove senior and junior concept. Performance of juniors will overtake seniors.

- Calculation shown in tables will help to identify teacher’s inefficiency under which category and subcategory facilitating opportunities for improvement and skill development It will also indicate in which category individual should improve to attain the maximum performance with less experience

- The evaluation using numerical values without statistical test/inference will provide overall outline due to the formulation of rules by giving weightage to parameters in the API categories.

- The overall performance of a faculty by using fuzzy logic model was found to be more realistic in the present method. While applying Fuzzy logic-the inference arrived for each category is different and the exact cut-off will help differentiate between groups and between individuals of the same group without any ambiguity.

## 7 Discussion

Higher educational Institutions rely on performance of teachers and many factors like teaching, student's feedback, use of innovative techniques in teaching learning process, research and publications effect the quality of teaching. The UGC prescribed format necessitates measurement of performance as APIs which has quantitative and qualitative parameters. The conventional methods are not effective in measuring the performance under uncertainty which can lead to improper decision making. Use of advanced technology such as soft computing models like fuzzy logic in assessment of performance of faculty facilitates expression of linguistic variables and help arrive at definite conclusions in the presence of vague, uncertain, ambiguous data.

Proper evaluation can help identify the strengths and weaknesses of faculty and provide opportunities for improvement and skill development. This model can help make decisions at times of promotions, salary hike, increments, even punishment, grievance handling, etc.

## 8 Recommendations

Higher education institutions rely on quality of teaching and measurement of which is a challenge for the administrators.

Faculty performance evaluation is an important task for administrators and use of effective evaluation techniques serves as a motivation factor for the faculty.

It also helps the organization to recognize the strengths and weakness and assess the contribution of employee to the institution.

Application of advanced technology such as soft computing models in HR activities can help overcome many challenges encountered in conventional methods in terms of transparency and efficiency thereby increasing the reliability

Fuzzy logic has proved to be particularly useful in expert system and other artificial intelligence applications and the same has been applied to evaluate faculty performance in higher education institutions.

Findings from the study support the use of fuzzy logic in faculty evaluation as one of the reliable methods to arrive at decisions.

Fuzzy logic reasoning reflects the way of human-thinking and in the presence of imprecise data it serves as an effective tool to measure faculty performance and aid in decision making at times of promotion, increments and transfers, etc.

### Acknowledgement

I would like to acknowledge the support and encouragement of university authorities in carrying out the study. I thank Professor Balasubramanian, Director Research, Dean, Faculty of Life Sciences, JSS University for guiding the study. I would also thank Professor Sridhar, Ramakrishna Mission Vidyalaya for his contributions and support in carrying out this study. I also extend my heartfelt thanks to my family for their encouragement and support in all my endeavours.

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