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Evaluating the Performance of Teaching Staff in Applied Colleges Using Fuzzy Logic

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Abstract

Using conventional approaches that evaluate teaching and research activity primarily based on numerical scores makes it harder and harder to evaluate academic success at various levels. The need for sophisticated computer models, such as the expert systems based on fuzzy Logic proposed in this study, which address the evaluation of teachers even in the face of ambiguous information, has been brought on by the indexing of academic performance in numerous international databases with impact indices at different scales. The development of a fuzzy Logic model in this study, which makes a unique contribution, involved simulating and implementing an algorithm in MATLAB, in which the membership functions and inference of fuzzy Logic rules designed. This pilot study's outcome was to test and validate the suggested model using a graphical interface, providing the results in accordance with minimum requirements and with more explanations.

Keywords: *Fuzzy Logic, Professors Performance, Evaluation, Fuzzy Logic, Feedback.*

1. Introduction

The effectiveness of the teaching staff is assessed during classes in higher education institutions. The-se assessments have become vital to raise the standard of in-strtion by identifying teachers' areas of strength and providing insight into their areas of weakness. profes-sor's quality could be viewed as a combination of their various abilities, expertise, and personal experiences that they offer to the classroom. For the purpose of using knowledge and skills in various effective assess-ment procedures, it incorporates knowledge of teaching in a certain topic or area [1,2]. Plan-ning, coordination, and evaluation of each faculty member's performance in an educational institution are required. These evaluations can take many different forms, including student feedback, peer assessment, and academic exam results. It is important to distinguish between teacher quality and teaching quality when evaluating faculty performance and student accomplishments based on research benefits[3,4].

The traditional ways of evaluating faculty performance based on student feedback are not scalable for the creation of automated systems, and traditional assessment methods occasionally confront challenges such consuming more time and leading to calculation errors. To prepare and integrate review areas, such as receiving student feedback, management assessment based on institute or university outcomes, in order to check the performance of faculty teaching abilities or performance in educational institutions. On the other hand, managing dataset uncertainty can be done using a fuzzy-based approach. Various approaches, like the Neuro Fuzzy System, have been used by numerous researchers to try and tackle this problem [5]. The main aim of this research paper is to evaluate the professors' academic performance for a subject into grade. The approach of a fuzzy logic techniques and fuzzy rule inference is used in this study. During the academic session or semester many uncertainties occur while executing the examination and continuous evaluation activities from both side i.e. a student or a teacher/institute. To handle such type of imprecise data for evaluation of professors' performance FL technique gives the more suitable and reliable result. Thus, FL provide an alternative way of evaluation of teacher's performance in the educational institute for handling the all kinds of uncertainties occur during the session. [6]

In this study the fuzzy inference system for performing faculty evaluations based on student feedback and for aiding in performance appraisal decisions to exercise professional judgment in evaluating its employees in educational institutions or universities. This is done because FMIS has the most features that are suitable for human inputs, easier to understand rule bases, and widespread acceptance. Each rule's output in a Mamdani Inference System is a fuzzy set.

2. Background on Fuzzy Logic

This section presents a literature review of works in this field that make use of diverse methodologies, including artificial intelligence and soft computing algorithms and machine learning techniques. An example of one of these methods is a fuzzy logic system. Because of the interference, that system is extraordinarily effective at processing uncertainty or ambiguity. For the investigation of faculty teaching abilities in academic or educational institutions, the authors of [7] developed an Inference System of Fuzzy Mamdani system. Fuzzy logic is frequently utilized to solve ranking issues in practical contexts. This approach is frequently criticized for failing to address the inherent ambiguity and imprecision involved with the mapping of the decision-maker's perception to precise values, despite its popularity and conceptual simplicity. Personal judgments are represented with clear values in the classical logic formulation. However, the human preference model is hazy in many real-

world situations, and decision-makers could be hesitant or unwilling to give comparison judgements clear values. One of the issues with the crisp assessment method is the requirement to use crisp values. One explanation is that decision-makers frequently convey their judgments as intervals rather than as single numerical values because they feel more comfortable doing so. Some criteria are typically overlooked throughout the evaluation process because they are challenging to quantify with precise values. The use of crisp value in mathematical models is another factor. These techniques are unable to address the ambiguities, uncertainties, and vagueness that decision-makers exhibit and which cannot be resolved by clear values. The incorporation of unquantifiable information, incomplete information, unattainable information, and partially ignorant facts into decision models is made possible by the application of fuzzy set theory. Fuzzy Logic and its expansions were created as a result to address ranking and justification issues. In order to determine how close a specific alternative is to the optimal answer, fuzzy logic is used. Alternatives may be separated by a positive or negative distance. The Fuzzy Positive Ideal Solution (FPIS), which represents a project profit, and the Fuzzy Negative Ideal Solution (FNIS), which represents a project cost, are calculated by the procedure. The option with the greatest distance from the negative-ideal solution and the shortest distance from the positive-ideal solution is chosen by the procedure. Fuzzy logic is based on the premise that people frequently draw conclusions based on insufficient data. Fuzzy models or sets are examples of mathematical techniques for describing ambiguity and imprecise information. These models can recognize, represent, handle, comprehend, and make use of ambiguous and uncertain facts and information. [5,7]

The fuzzy rule base, fuzzy inference engine, fuzzification, and defuzzification are the four basic parts of the fuzzy Logic system. A set of fuzzy IF-THEN rules make up the fuzzy rule base. There are a variety of fuzzy inference systems, however in this article the Mamdani inference mechanism was chosen to assess the performance of a security system since it is frequently simple and appropriate to develop systems that fall within the necessary parameters. On the basis of student comments, a system for assessing faculty members' teaching abilities is suggested. In this work, a ranking approach based on the feedback elements for teachers' performances is proposed.

This method uses a variety of fuzzy operators to compute the answer to fuzzy relationship equations. To achieve this goal, FREs in particular, in which linguistic variables are specified to deal with factor uncertainty, are used [8]. O.K. Chaudhari et al.'s fuzzy expert system was proposed for the evalu-ation of faculty overall performance using "uncertain facts or data" in the decision-making process. It teaches the fuzzy logic principles that academics may use to assess the performance of teachers.

The yearly academic Annual Confidential Reports (ACR) in an educational institution will be written with the assistance of this research [9]. When evaluating teachers' performance at academic institutions, Yadav et al. [10] devised a fuzzy logic approach. This study offered a methodology that, in addition to analyzing the academic performance of students and faculty, offers a wide variety of diverse uses for academic or educational institutions. An Expert System with Fuzzy Logic in Teacher's Performance Evaluation has been proposed by Khan, Abdur Rashid et al. [11,12]. This study uses fuzzy logic to manage qualitative and ambiguous data or facts in the decision-making process, which is a variation on expert system technology. The fuzzy logic mathematical idea is explained in the paragraphs that follow:

Step 1: Establishing the terms used in linguistics, membership functions, and the importance of the evaluation criteria. For each criterion, identify the language variables. Each linguistic variable is given a set of membership functions, which are used to calculate the weights of the assessment criteria and the ratings of the alternative options. Create the fuzzy decision matrix in step two. The criteria alternatives and linguistic variables are intimately related to the decision matrix. Assuming that there are n criteria and m projects, a fuzzy decision matrix with m rows and n columns will be produced. This matrix looks like this:

$$\bar{D} = \begin{bmatrix} \bar{X}_{11} & \bar{X}_{12} & \cdots & \bar{X}_{1n} \\ \vdots & & \ddots & \vdots \\ \bar{X}_{m1} & \bar{X}_{m2} & \cdots & \bar{X}_{mn} \end{bmatrix} \quad (1)$$

$$\bar{X}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \quad (2)$$

Where: a, b, c is alternatives, quality of teachers which must be ranked according to established criteria i, j, Xi,j is the rating of alternative , a, b, and c :[13]

3. Proposed Model

This section describes in detail the proposed approach of applying Fuzzy Logic System to analyze the evaluation professors, wherein the first subsection explains the applying of the FLS, and the pros and cons of this approach, in addition it presented an evaluating criteria's with discussing the different tasks engaged in evaluating analysis.

The experts should choose criteria to assess a evaluating system's capacity to identify the criteria and its weight. This study advocated employing verbal concepts, which are specified by specialists in the form of linguistic variables, as the most significant criteria to evaluate the effectiveness and performance of professors. To determine the effectiveness of an evaluating system, the experts should select criteria that determine the capabilities of the system to evaluate the professors, the very important criteria's which are defined by the experts in the form of linguistic variables:

- V_1 – Manage lecture time efficiently,
- V_2 – Commitment to the times allotted for the lecture,
- V_3 – Use appropriate teaching aids,
- V_4 – Clearly explain and cover the course contents and objectives,
- V_5 – Encouraging extra-curricular activities,
- V_6 – Interact with students and the ability to attract students' interest and hall tuning

Experts consider each of the criteria as a linguistic variable (V). In this work, the selected criteria will be determined at the verbal level by the following linguistic variables (LV) and term-sets as inputs for fuzzy Logic as mention in table 1.

Table [1]: Fuzzy Set of Input Variables

Inputs Variable	Criteria	Linguistics
V1	Manage lecture time efficiently 10	Excellent Good Poor
V2	Commitment to the times allotted for the lecture 10	Excellent Good Poor
V3	Use appropriate teaching aids 20	Excellent Good Poor

Inputs Variable	Criteria	Linguistics
V4	Clearly explain and cover the course contents and objectives 20	Excellent Good Poor
V5	Encouraging extra-curricular activities 20	Excellent Good Poor
V6	Interact with students and the ability to attract students' interest and hall tuning 20	Excellent Good Poor

The output of the fuzzy model is the assessment of the effective-ness of professors' system and it will take the following fuzzy sets: Poor, good, and Excellent. After the determination all LVs and FVs, the membership functions of FV are given for Logical decision conclusion regarding the effectiveness of a professors' system. The experts are putting the correspondence table "criteria - the effectiveness of a professors' system", as shown in Table.2.

Table [2]: The Correspondence Table "Situation-Result"

№ rule	V1	V2	V3	V4	V5	V6	Result
1	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**
2	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good
3	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor
	…	…	…	…	…	…	Excellent
79	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good
80	Good	Good	Good	Good	Good	Good	Poor
81	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

.The input and output parameters in the Fuzzy Logic Toolbox environment are inserted as shown in Figure. 1.

4- Proposed Method for Professors Performance Evaluation

Performance is described as a rigorous review of teaching performance while taking into account an organizational context, in order to meet the key objectives of the system for the process of evaluating teachers. An intelligent fuzzy evaluation will assist specialists in developing management guidelines to make the best possible choice. Fuzzy Logic approaches will be used by an expert system in this study to evaluate the performance of the professors. To assess the effectiveness of faculty members through their involvement in the numerous sub-activities carried out at universities and institutions, a fuzzy based model is presented. As mentioned in the following section, the crisp data set in this research was converted into a fuzzy data set using the triangular membership function. The designed model is consisting of following steps.

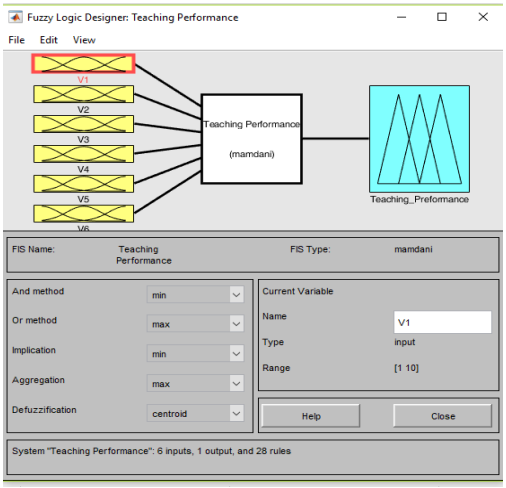

Figure [1]: The Input and Output Parameters in the Fuzzy Logic Toolbox

4.1. Crisp Data

The input variables data was collected from the students' feedback at end of the semester with respected the criteria mentioned in table 1.

4.2. Fuzzification (Fuzzy Input Data)

Using variables that are close to spoken human language, such as poor, good, exceptional, etc., six input variables (criteria) are fuzzified. The degree of connection for each input variable is then represented by a triangular. membership function, which is specified by a lower limit (a), an upper limit (d), a lower support limit (b), and an upper support limit (c), where a, b, c, and d represented in next equation (1).

$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x > d) \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases} \qquad (3)$$

4.3 Development of Fuzzy Rule and Inference Mechanism

To relate the inputs and output membership functions, fuzzy inference rules are used in inference process. These linguistics rules use "IF-THEN" statements. These rules are flexible and can be formulated depending upon the importance to be given to a particular input with the discussion with the academic experts.

4.4 Defuzzification of Fuzzy Output

The output variable Teaching Performance that mentions in figure 1, is final performance. If the six input variables are expressed as V1, V2, …, V6 and membership functions of these variables are μ(f1), μ(f2), μ(f3.) mentioned as Poor, Good and Excellent respectively figures 2-4 demonstrate membership function for some variables that mention below as a sample only. Remaining variables are seam.

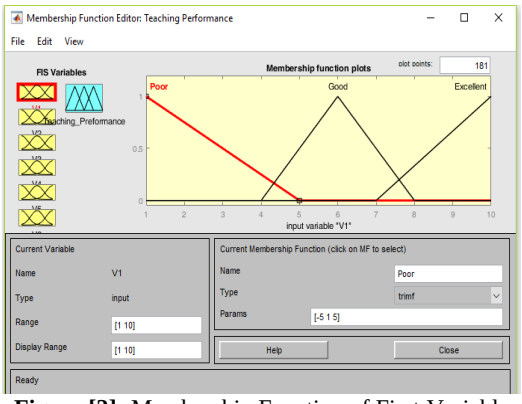

Figure [2]: Membership Function of First Variable

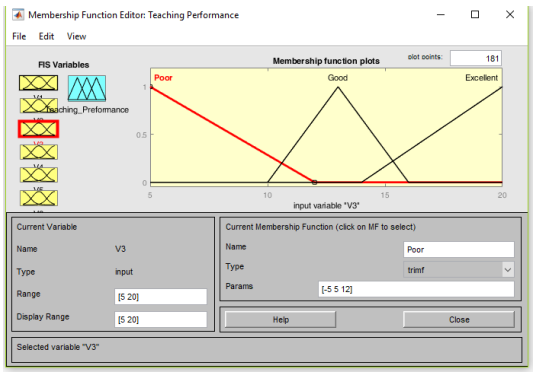

Figure [3]: Membership Function of Third Variable

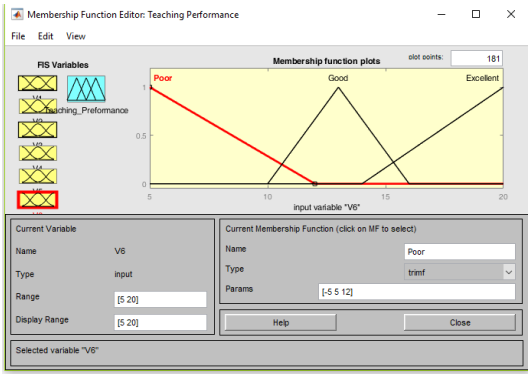

Figure [4]: Membership Function of Sixth Variable

The membership function of the output variable is given by equation (4)

$$\mu F(x) = Max\ k[\min[\mu(V_1), \mu(V_2), \mu(V_3), \ldots, \mu(V_6)]], k = 1, 2, 3, \ldots, r \quad (4)$$

This expression conveys the value of the membership function for the professors' performance output variable for each input's active rules. The six inputs are combined using the logical operator AND. In this research used the linguistic variables for output, which are shown in the next Table, in a manner similar to the fuzzy linguistic variables of the input

Table [2]: Professors' Performance in Terms of Linguistic Variable

Teaching Per-formance	Poor	Good	Excellent
Rate	<50	50 < P ≤70	≥70

The next figure shows the output membership function

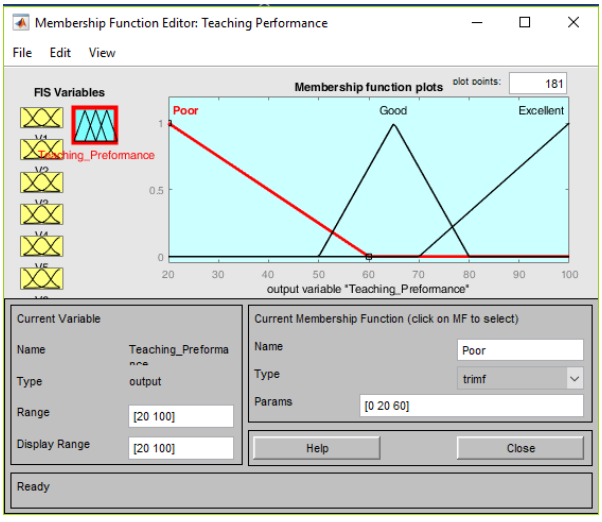

Figure [5]: Membership Function of the Output

Table [3]. Comparison Between Classical Method & Fuzzy Logic Method

Student ID	V1	V2	V3	V4	V5	V6	Classical Method	Fuzzy Logic Method
1	4	3	3	4	2	3	3.2	3.8
2	4	4	3	4	4	4	3.8	4
3	3	4	5	5	2	3	3.7	3.6
4	5	3	2	4	4	3	3.5	3.1
5	4	3	5	3	3	2	3.3	3
6	3	3	3	4	2	3	3	3.5
7	3	4	4	4	3	3	3.5	3.1
8	4	4	5	3	3	3	3.7	3.9
9	4	3	2	3	3	3	3	3.4
10	3	3	4	3	3	4	3.3	3.4
11	4	5	4	4	5	3	4.2	4.4
12	3	3	4	3	3	2	3	2.8

Table 3: Demonstrate the comparisons between classical method and fuzzy logic method for teaching performance evaluation. In classification method the evaluation of inputs of feedback is taken by standard mean deviation method.

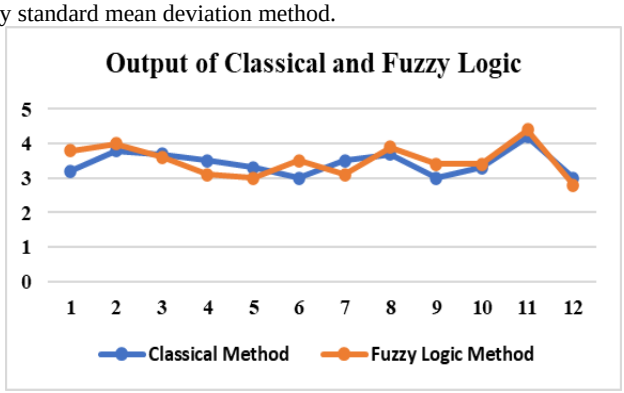

Figure 6: Graphical Representation Output Data of Classical and Fuzzy Logic Methods

The above figure shows that the graphical representation of output data of classical and fuzzy logic methods. Assessment of the classical method with fuzzy logic method exposes differences in the various performance values.

5. Conclusion

The using of traditional methods to assess performance in the face of ambiguity can result in poor decisions. The use of cutting-edge technology, such as soft computing models like fuzzy logic in teaching performance evaluation, makes it easier to describe language variables and aids in drawing firm conclusions in the face of hazy, unsure, and confusing data. An appropriate review can point out the faculties' assets and liabilities and offer prospects for growth. This approach can aid in making judgments regarding promotions, pay increases, increments, even punishment, addressing grievances, etc. This study evaluates the effectiveness of professors' lectures using fuzzy logic approaches. The outcome of the fuzzy logic method for evaluating teaching performance is compared with the classical method.

Data Availability
No data were used to support this study.

Conflicts of Interest
The authors declare that they have no conficts of interest.

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