Fuzzy Logic techniques for Interpreting and Evaluating Pedagogy of Teacher Behavior and Capability to Transform Knowledge into Practice

[1]Jagmohan Mago, [2]Neeru Mago
[1]Department of Computer Science & Applications, Apeejay College of Fine Arts
Jalandhar, India, [2]Department of Computer Science & Applications, PUSSGRC, Hoshiarpur, India
Emails : magojagmohan@gmail.com, neerumago80@gmail.com

Abstract:

Current literature and common practices suggest that there is no consistent method available to interpret and evaluate the performance of a teacher. Due to its inherent vagueness and uncertainty, this research work aims to analyze the effectiveness of teacher depending upon various factors influencing quality of teacher using fuzzy logic. The first part studies various factors of professional behavior, interpersonal behavior and personal behavior of the teachers from student's perspective to impart quality education. In the second part, fuzzy inference mechanism as suggested by Mamdani is designed and developed to decide the possible quality of performance of teacher from student's point of view. The paper concludes by observing that the proposed fuzzy logic based interpretation of comprehensive quality of performance of teacher is consistent with those judged by the experts in the field and can be used to predict the possible quality of teachers

Keywords-Teacher behavior; Teacher evaluation; Academic development; Students achievement; Fuzzy Logic; Chi-Square

Introduction

Sustainable development of any country is possible only if the education provided is of very high quality and to achieve this objective, comprehensive development of teachers needs to be reviewed from time to time. The comprehensive development of an academician is examined and presented in the literature in various forms. The comprehensive development is about academicians understanding, understanding how to learn, and transforming knowledge into practice for promoting students' development. There is thus a constant need to analyze, discuss and study the educational requirements of varied student groups, the expectations of the prevailing education systems, the working conditions for the teachers and the opportunities to learn.

The first part of this research article studies various aspects of professional skills, interpersonal skills and personal skills of the teachers from student's perspective and provides a bird's eye view about the technique of Fuzzy Logic to predict teachers' comprehensive professional development in teaching. The professional behavior includes the subject knowledge, the delivery of the subject knowledge to students and the creativity to transform the knowledge into practice. The interpersonal behavior constitutes the communication skills, adaptation to teaching environment and ability to motivate and inspire the students to excel in life. It is rightly said that actions speak louder than words. Personal skills consist of the punctuality and the conduct of teacher in the classroom and these skills always leave long lasting impact on the personal and professional lives of students.

All the factors examined in first phase contribute to levels of inconsistency in evaluating the holistic development of teachers. In the second part, fuzzy inference mechanism as suggested by Mamdani is designed and developed to decide the possible quality of performance of teacher in the classroom environment.

The paper concludes by observing that the proposed fuzzy logic based interpretation of comprehensive quality of performance of teacher is consistent with those judged by the experts in the field and can be used to predict the pedagogy of teacher behavior and the capacity to transform knowledge into practice. The Chi-square test of homogeneity was conducted on 200 randomly selected samples from the population of 1050 participants and found that the results proposed by the decision support system using fuzzy logic are consistent with the human experts and thus the aim to design and develop a decision support system to analyze the professional development of teachers in the class room environment from students' perspective is achieved.

Literature Survey

Based on reviews of effective teachers' behavior research, (Van de Grift, 2007; Maulana, Opdenakker, Stroet & Bosker 2013) identified six areas of teaching quality. These areas constitute safe and stimulating learning climate, efficient classroom management, clarity of instruction, activating learning, adaptation to students' learning needs, and teaching learning strategies. These six areas of teaching quality are also in accordance with other empirical findings and models (Danielson, 2013; Ko & Sammons, 2013; Pianta & Hamre, 2009). In the proposed research, quality of teachers is studied on three broader domains. These domains constitute professional skills, interpersonal skills and personal skills. In short, professional skills, personal skills and interpersonal skills are three important aspects in determining teacher effectiveness in the classroom environment. It can be concluded from the research that the three broad categories further depend on nine parameters as shown in Table 1.

TABLE I. CATEGORIES & FACTORS TO MEASURE TEACHING QUALITY

S.No.	Categories	Factors
1.	Professional Skills	Knowledge Knowledge Delivery Creativity
2.	Interpersonal Skills	Adaptive Communication Skills Motivator Inspirational
3.	Personal Skills	Conduct Punctual

Methodology

A fuzzy logic based model has been proposed to analyze and interpret teachers' capabilities based on Saleh & Kim, 2009 and Chen & Li, 2011 fuzzy logic model for evaluating students' learning achievement. The block diagram of the proposed fuzzy logic based inference systems is shown in Fig. 1.

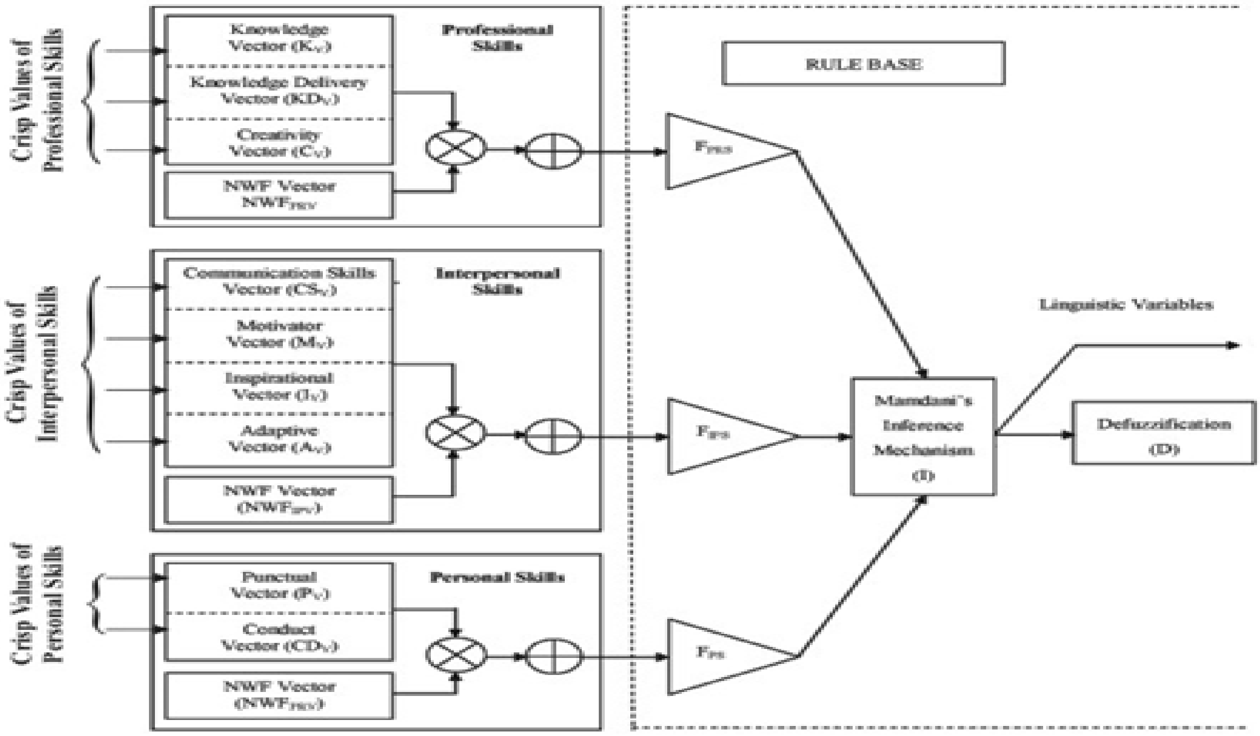

Figure 1. Proposed model to evaluate comprehensive quality of teachers in classroom environment

The system consists of two phases:

- Phase 1: The user provides the crisp values of nine parameters that are constituents of three broad categories. These values are multiplied by their respective normalized weights. The sum of these products becomes the input to the fuzzy inference system.
- Phase 2: The crisp values of professional skills, interpersonal skills and personal skills are thus fuzzifed using the defined fuzzy sets. The crisp value of the output is deduced from Mamdani's inference mechanisms. The crisp value can further be interpreted in the form of linguistic terms.

A. Sample and Procedure

The data was drawn from a group of 1050 experts from students, parents and experts from the college managements. The group was asked to fill in the information on teaching quality voluntarily. The students were from medical, engineering and arts streams. It has been found that the perspective of the students about the teacher varies with stream. The expectations of students from the teachers securing more marks are different from the students securing relatively less marks in the university exams. This research was student centric so there were 900 students out of 1050 experts were considered. It is also required to address the expectations of parents and college managements from teachers, so 100 parents who were at least graduate and 50 experts from various college managements were taken into the panel to access the quality of the performance of teachers in the class room environment as shown in Table II.

TABLE II. GROUP OF EXPERTS FOR COLLECTING DATA

Sr. No.	Categories	No. of Experts
1.	Engineering Students Securing more than 80% Securing between 60-80% Medical Students Securing more than 80% Securing between 60-80% Arts Students	 150 150 150 150

	Securing more than 80% Securing between 60-80%	150 150
2.	Parents (at least Graduate)	100
3.	Experts from Managements	50
	Total	1050

B. Normalized weight factor (NWF) for parameters and Synthesis of priorities using AHP

To capture groups' perception of teachers' performance quality, we designed an input form on performance quality and their order of preference was acquired. The form was based on a standardized observation instrument on teachers' performance in the class room environment (Maulana, Helms-Lorenz & Van de Grift, 2015a; Maulana, Helms-Lorenz & Van de Grift, 2015b). The form measures three areas of teaching skills in nine items configuration: Professional Skills (3 items, example: knowledge, knowledge delivery), Interpersonal Skills (4 items, example: Communication skills, Adaptive) and Personal Skills (2 items, example: Conduct). All items were provided on a 9 point scale ranging from 1 (Most Preferred) to 9 (Least Preferred). The form has been reported to be consistent and reliable measure of teachers' performance quality. One thousand fifty forms were filled to collect the data and the compiled results are shown in Table III.

The data showed that 507 experts ranked factor *knowledge* as 1, 283 ranked it as 2 and so on. For the present sample, we analyzed consistency of measure using Analytic Hierarchy Process (AHP). Weight of the factor (WF) influencing the quality of an academician can be calculated using Eq. (1) and the normalized weight of a factor (NWF) can be calculated using Eq. (2). Table 4 shows the WF and the NWF of the parameters influencing the quality of an academician.

TABLE III. PREFERENCE OF THE FACTORS

Categories	Factors(F)	Rank(R)								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Professional Skills	Knowledge	507	283	124	67	18	17	13	5	16
	Knowledge Delivery	335	335	107	105	84	36	7	12	29
	Creative	117	124	85	145	130	96	167	88	98
Interpersonal Skills	Adaptive	75	110	184	114	133	81	86	113	154
	Motivator	191	214	146	154	104	118	67	25	31
	Inspirational	98	175	167	103	104	125	112	127	39
	Communication Skills	236	207	293	135	54	21	38	24	42
Personal Skills	Punctual	173	164	135	166	88	92	99	68	65
	Conduct	119	128	106	84	146	135	73	114	145

$$WF[F]=\left(\sum_{I=1}^{9}\left(\sum_{w=9,J=1}^{w=1,J=9} F[I][J]\times w\right)\right)/\sum_{w=1}^{9} w \qquad (1)$$

where *WF[F]* is the weight of the factor *F*, *F[I][J]* is the frequency of preference at *I* of factor *F*.

$$NWF[F]=(WF[F]\times 10)/\sum_{I=1}^{a} WF[I] \qquad (2)$$

where *NWF[F]* is the normalized weight of factor *F*, *a* is the number of constituent factors in the category.

TABLE IV. NORMALIZED WEIGHT FACTOR(NWF) OF FACTORS

Categories	**Factors**	**Weight Factor (WF)**	**Normalized Weight Factor NWF=(WF*10)/(Total WF)**
Professional Skills	Knowledge	7.92	(7.92*10)/20.33 = 3.896
	Knowledge Delivery	7.34	3.610
	Creative	5.07	2.494
	Total	20.33	
Interpersonal Skills	Adaptive	4.91	(4.91*10)/23.55 = 2.085
	Motivator	6.33	2.688
	Inspirational	5.45	2.314
	Communication Skills	6.86	2.913
	Total	23.55	
Personal Skills	Punctual	5.82	(5.82*10)/10.78 = 5.3989
	Conduct	4.96	4.6011
	Total	10.78	

For the present sample, we analyzed consistency of measure using Analytic Hierarchy Process (AHP). According to AHP, pair-wise comparison matrix is used for the calculation of eigenvector and maximum Eigen value (λ_{max}). The eigenvector represents the relative importance amongst factors and λ_{max} is used to measure consistency ratio. The step wise description is as follows:

Step 1: Defining Pair-Wise Comparison Matrix (CM)

CM = 1-(U (A, B)-U (B, A)) , if U (A, B) > U (B, A),

= 0, otherwise

= 1, if comparing same factors (A=B), where, for U(A,B) quantifies, A is preferable to B.

Step 2: Calculation of priority weights or eigenvector.

Let W= (w_1, w_2, w_3, ……w_n)^T, be the priority weights of CM and can be computed using eq. (3)

$$w_i = S_i / \sum_{i=1}^{n} S_i \qquad (3)$$

where $S_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}, i = 1, 2, 3, ..., n$ and a_{ij} is the values in CM.

Step 3: Computation of maximum Eigen value (λ_{max})

It can be computed using eq. (4)

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(AW)_i}{W_i} \qquad (4)$$

Step 4: Consistency Index (CI) for the comparison matrix can be computed using eq. (5)

$$CI = (\lambda_{max} - n)/(n - 1) \quad (5)$$

where n is the order of comparison matrix.

Step 5: Compute consistency ratio (CR) using eq. (6)

$$CR = CI/RI \quad (6)$$

Generally, the comparison matrix is considered to be consistent if CR<0.1of the comparison matrix of order 4x4 or less. RI is the known random consistency index. Table V shows the values of RI for comparison matrices of order 1 to 10 (Saaty, 2000).

TABLE V. VALUES OF RI

Order of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Consistency Index and consistency ratio of factors of professional skills, interpersonal skills and personal skills of teachers are computed as shown in Table VI. It can be concluded that the evaluation within the matrix is acceptable and it indicates a fine level of the consistency in the comparative judgments represented within the matrix.

TABLE VI. CONSISTENCY OF MEASURES

Categories	**Weight Vector**	**Max. Eigen Value**	**Consistency Index**	**Consistency Ratio**
Professional Skills	[0.3133,0.5935,0.09313]	3.0919	0.0459	0.079<0.08
Interpersonal Skills	[0.1038,0.1610,0.2836,0.4517]	4.0476	0.0159	0.018<0.1
Personal Skills	[0.1228,0.8772]	2	0	0=0

C. Evaluation methods using fuzzy logic

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled. The term "fuzzy logic" emerged in the development of the theory of fuzzy sets (Zadeh, 1965; Dubois, Lang & Prade, 1991). Fuzzy Logic is a type of multi-valued logic. It is developed from fuzzy set theory to deal with reasoning and uncertainty and is vague and imprecise (Bellman & Zadeh, 1977). Fuzzy Membership functions and fuzzy rules are used instead of traditional bi-valued logic in Fuzzy Logic (Ross, Booker & Parkinson, 2002; Allahverdi, 2002). Generally, membership function is denoted by the Greek symbol 'μ'. For instance, given the intensity of knowledge of teacher as input 'x', its membership function is denoted by $0.2 = \mu_{Average}(x)$. In consultation with domain experts or from existing data fuzzy sets can be derived. The concept of smooth boundaries was first suggested by Prof. L. A. Zadeh and developed a type of mathematics which could be used to help solve real world problems. By developing the concept of fuzzy sets, it permitted the evolution of mathematics such that they could be used to compute output using inference mechanisms (Mamdani, 1974, Takagi–Sugeno–Kang, Siler & Buckley, 2005; Yen & Langari, 1998). This development allows membership values to range between the values 0 and 1, [0, 1] rather than discrete values of 0 or 1, {0, 1} which had traditionally existed in two-valued Boolean logic.

In this research, we propose a fuzzy logic based evaluation of teachers considering the professional skills, interpersonal skills and personal skills. The capability of fuzzy logic to deal with uncertainty and vagueness prompted us to use fuzzy logic as a tool to evaluate comprehensive performance of teachers. Values of the factors comprised by professional skills, interpersonal skills, and personal skills of teachers assigned by domain experts are the basis for evaluation. The values are in the range of 0 to 10.

Assume that there are n teachers to be evaluated on the basis of knowledge, knowledge delivery, and creativity. Professional skills of teachers' scores (domain experts assign the scores of knowledge, knowledge delivery, and creativity in the range 01 to 10) are the basis for evaluation. Combining knowledge vector K_V, knowledge delivery vector KD_V, and creativity vector C_V, we get the professional skills matrix of dimension 3×n,

$PRS = [prs_{ij}]$

where i = 1 is K_V, i=2 is KD_V, and i=3 is C_V to 3, j = 1 to n, $[prs_{ij}] \in [0,10]$ denotes the professional skills of teacher j.

Normalized weight factor (NWF) of various factors constituting professional skills is shown in Table 3.

$NWF_{PRV} = [3.896, 3.610, 2.494]$

It represents the maximum sum of factor *i* satisfies $\sum_{i=1}^{3} NWF_{PRV}(i) = 10$

Interpersonal skills matrix of teacher constitutes Motivator vector M_V, Inspirational vector I_V, Adaptive vector A_V, and Communication skills vector CS_V.

$IPS = [ps_{ij}]$

where i = 1 is A_V, i=2 is M_V, i=3 is I_V to 3, and i = 4 is CS_V, j = 1 to n, $[ps_{ij}] \in [0,10]$ denotes the interpersonal skills of teacher j.

Normalized weight factor (NWF) of various factors constituting interpersonal skills is shown in Table 3.

$NWF_{IPV} = [2.085, 2.688, 2.314, 2.913]$

It represents the maximum sum of factor *i* satisfies $\sum_{i=1}^{4} NWF_{IPV}(i) = 10$

Similarly, Personal skills matrix constitutes punctual vector P_V and conduct vector CD_V.

$PS = [ps_{ij}]$

where i = 1 is P_V, and i=2 is CD_V, j = 1 to n, $[ps_{ij}] \in [0,10]$ denotes the personal skills of teacher j.

Normalized weight factor (NWF) of various factors constituting personal skills is shown in Table 3.

$NWF_{PV} = [5.3989, 4.6011]$

It represents the maximum sum of factor *i* satisfies $\sum_{i=1}^{2} NWF_{PV}(i) = 10$

ISSN: 2229-6913 (Print), ISSN: 2320-0332 (Online), UGC Approved Journal (S.No.63019)
Web Presence: http://www.ijoes.vidyapublications.com

Based on professional skills matrix PRS, interpersonal skills matrix IPS and personal skills matrix PS and respective normalized weight factor vectors NWF_{PRV}, NWF_{IPV}, and NWF_{PV}, we computed the respective score vector of dimensions n ×1.

$SPR = PRS^T \times NWF_{PRV} = [SPR_j]$, n×1, where $SPR_j \in [0,100]$

$SIP = IPS^T \times NWF_{IPV} = [SIP_j]$, n×1, where $SIP_j \in [0,100]$

$SPS = PS^T \times NWF_{PV} = [SPS_j]$, n×1, where $SPS_j \in [0,100]$

SPR_j, SIP_j and SPS_j are the total scores of teacher j in professional skills, interpersonal skills and personal skills respectively. In this paper, V^T represents the transpose of vector V.

Process 1 (Fuzzyfication). Crisp values of performance levels based on professional skills, interpersonal skills and personal skills of teachers are then obtained and are represented by $\mu_{FPRS}(i)$, $\mu_{FIPS}(i)$ and $\mu_{FPS}(i)$ respectively.

$SPR = \mu_{FPRS}(i) \in [0,100]$ denotes the fuzzy input membership value of the professional skills of teacher i,

$SIP = \mu_{FIPS}(i) \in [0,100]$ denotes the fuzzy input membership value of the interpersonal skills of teacher i and

$SPS = \mu_{FPS}(i) \in [0,100]$ denotes the fuzzy input membership value of the personal skills of teacher i.

In this paper, five levels of Fuzzy membership functions (Saleh & Kim, 2009) of professional skills are used; level =1 for linguistic variable ‘‘low”, level = 2 for ‘‘more or less low”, level = 3 ‘‘medium”, level = 4 for ‘‘more or less high”, and level = 5 for ‘‘high”. Their Membership functions are explained in Fig. 2. The same five fuzzy membership functions are used to the interpersonal skills, the personal skills and the output variable (quality of teacher (Qt)).

Process 2 (Inference Mechanism). In this process, based on fuzzy input values of professional skills $\mu_{FPRS}(i)$, interpersonal skills $\mu_{FIPS}(i)$ and personal skills $\mu_{FPS}(i)$ of teacher *i* and the fuzzy rules, RD, comprehensive quality of the teacher is inferred. Fuzzy sets for defuzzification are produced using max–min inference mechanism as proposed by Mamdani. It can be written as in eq. (7)

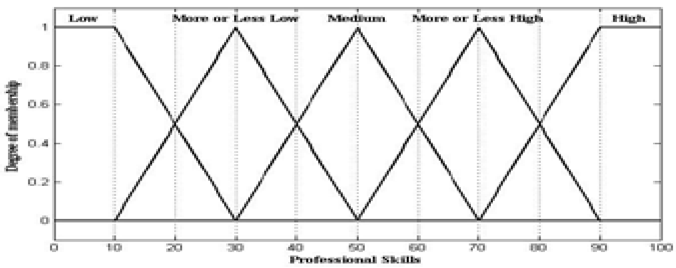

Figure 2. Five Levels of Fuzzy membership functions.

$$\alpha_{ij} = \max_{\{(l_1,l_2,l_3)R(l_1,l_2,l_3)=j\}} \{\min(\mu_{FPRS}(i)l_1,\ \mu_{FIPS}(i)l_2\ ,\ \mu_{FPS}(i)l_3)\} \qquad (7)$$

where α_{ij} is the output of inference of quality of performance of teacher *i* in the fuzzy set *j*.

Process 3 (Defuzzification). In this process, the output is quantified based on the given fuzzy sets and the membership values. In this paper, the Center of Area CoA(Qt) method is applied to quantify the quality of teacher i. This is represented in eq. (8).

$$CoA_i = \int (x \times \mu(x)dx / \int \mu(x)dx \qquad (8)$$

CoA is a reasonably acceptable crisp value of quality of performance of teacher *i*. For deciding the quality of teacher, we check

if 0≤ CoA(Qt) ≤ 20 then the TeacherQuality is Low
if 20<CoA(Qt) ≤40 then the TeacherQuality is More or Less Low
if 40<CoA(Qt) ≤60 then the TeacherQuality is Medium
if 60<CoA(Qt) ≤80 then the TeacherQuality is More or Less High
and if 80<CoA(Qt)≤100 then TeacherQuality is High.

D. Implementation

The graphical user interface (GUI) has been designed and developed using MATLAB to receive the inputs from the students and to display possible quality of the teacher. The values of the various parameters provided by the students, using the designed GUI at the time of evaluation, are considered as inputs and the corresponding quality as output. These inputs are provided to the system in the form of values for knowledge, knowledge delivery, communication skills, adaptive, motivator, creative, punctual, inspirational and conduct. The values of these parameters will range from 0 to 10 (0 being the lowest and 10 being the highest). These inputs are passed to the fuzzy inference system (FIS) which then processes the inputs and produces the output

Results and Discussion

The application of conventional Boolean logic in human reasoning may cause inability to evaluate the degree of quality of the input variables and thus the degree of overall quality of a teacher when attempting to evaluate the quality of education being imparted to students. This is because of imprecision and vagueness inherent in the evaluation of the quality of performance of teacher. However, FL provides a mathematical method for representing such imprecise information. The following example explains the working of the proposed system.

Example. Assume that 5 teachers are to be evaluated. A Student supplies the following professional skill matrix, interpersonal skill matrix, personal skill matrix.

$$PRS = \begin{pmatrix} 4 & 9 & 8 & 3 & 8 \\ 8 & 3 & 5 & 2 & 9 \\ 1 & 5 & 3 & 6 & 10 \end{pmatrix} \quad IPS = \begin{pmatrix} 2 & 3 & 9 & 5 & 2 \\ 4 & 3 & 10 & 5 & 9 \\ 9 & 4 & 3 & 8 & 4 \\ 4 & 2 & 10 & 5 & 8 \end{pmatrix} \quad PS = \begin{pmatrix} 8 & 4 & 6 & 3 & 8 \\ 6 & 2 & 10 & 5 & 9 \end{pmatrix}$$

Their respective normalized weight factor vectors are

NWF_{PRV} = [3.896, 3.610, 2.494]
NWF_{IPV} = [2.085, 2.688, 2.314, 2.913]
NWF_{PV} = [5.3989, 4.6011]
$SPR = PRS^T \times NWF_{PRV}$
$SPR^T = \mu_{FPRS}(i) =$ [46.96 58.36 56.70 33.87 88.60]
$SIP = IPS^T \times NWF_{IPV}$
$SIP^T = \mu_{FIPS}(i) =$ [47.40 29.40 81.72 56.94 60.92]
$SPS = PS^T \times NWF_{PV}$
$SPS^T = \mu_{FPS}(i) =$ [70.80 30.80 78.40 39.20 84.60]

Total scores in professional skills, interpersonal skills and personal skills are then obtained by 5 teachers are as shown in Table VII.

TABLE VII. SCORES OF FIVE TEACHERS

Categories (Skill Set)	Teachers				
	T1	T2	T3	T4	T5

Professional Skills	46.96	58.36	56.70	33.87	88.60
Interpersonal Skills	47.40	29.40	81.72	56.94	60.92
Personal Skills	70.80	30.80	78.40	39.20	84.60

The inference mechanism, after setting these inputs as metrics to measure the quality of five teachers, concludes that the quality of performance of five teachers are "Medium", "More or Less Low", "More or Less High", "More or less Low", and "More or less High" respectively. Since, the universe of discourses for the inputs are [0, 10], this makes it easier for students and other stake holders to assume values in number rather than [0, 1]. Values supplied by stake holders while experimenting are approximate, hence vague and thus, highly suitable to a system such as that have been proposed in this research.

Illustration: The fifth teacher scores 88.60, 60.92 and 84.60 in professional skills, interpersonal skills and personal skills respectively. These values are supplied to the Mamdani's Inference Mechanism and the following rules are fired from the Rule Base as shown in Fig 3.

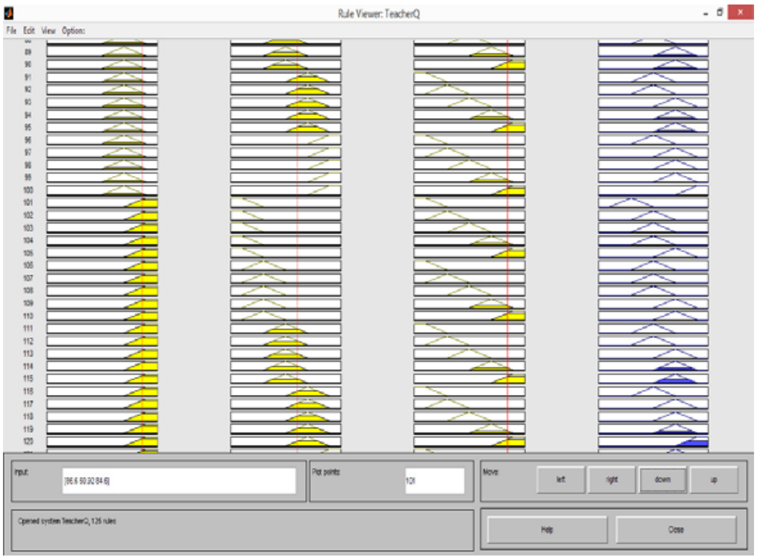

Figure 3. Rule View of Teacher Quality implemented in MATLAB

The defuzzified value (CoA) of the *Teacher Quality* inferred is $78.5 \in (60,80]$. Thus the Quality of teacher comes out to be "More or less high".

R_{89}: If (FPRS is MLHigh) and (FIPS is MED) and (FPS is MLHigh) then (TeacherQuality is MLHigh)
R_{90}: If (FPRS is MLHigh) and (FIPS is MED) and (FPS is High) then (TeacherQuality is MLHigh)
R_{94}: If (FPRS is MLHigh) and (FIPS is MLHigh) and (FPS is MLHigh) then (TeacherQuality is MLHigh)
R_{95}: If (FPRS is MLHigh) and (FIPS is MLHigh) and (FPS is High) then (TeacherQuality is MLHigh)
R_{114}: If (FPRS is High) and (FIPS is MED) and (FPS is MLHigh) then (TeacherQuality is MLHigh)
R_{115}: If (FPRS is High) and (FIPS is MED) and (FPS is High) then (TeacherQuality is MLHigh)
R_{119}:If (FPRS is High) and (FIPS is MLHigh) and (FPS is MLHigh) then (TeacherQuality is MLHigh)
R_{120}:If (FPRS is High) and (FIPS is MLHigh) and (FPS is High) then (TeacherQuality is High)

A. Statistical Analysis

Using stratified random technique 200 test cases were selected as shown in Table VIII. For these sample cases tested, the responses of the system and the experts were collected and tabulated as shown in Table IX.

Quality of Performance of teacher	System (Observed O_i)	Expert (Expected E_i)	$(O_i-E_i)^2/E_i$
Low	27	33	1.090909
More or less Low	39	42	0.214286
Medium	62	68	0.529412
More or less High	40	31	2.612903
High	32	26	1.384615
Total			$\chi^2 = 5.832125$

To verify the homogeneity of the two observations, a Chi-square test of homogeneity of variance was applied:

Hypothesis:

X_0: Samples from the experts and the proposed model are not significantly different.

X_A: Samples from the experts and the proposed model are significantly different.

For this analysis, let significance level p = 0.01

Test Statistics: The test statistics is $\chi^2 = \Sigma[(O_i - E_i)^2/E_i]$.

Distribution of test statistics: Degree of freedom = (5-1) = 4

Decision Rule: Accept X_0 if the computed value of χ^2 is less than 13.277.

Decision: Calculated χ^2 values is 5.83 and is less that the critical value 13.277. The Null Hypothesis is accepted. So it can be concluded that the comprehensive quality of teachers estimated by the proposed system and the suggested quality of teachers by the experts are homogeneous.

TABLE VIII. TEST CASES FOR VERIFYING THE HOMOGENEITY

Sr. No.	Categories	No. of Experts
1.	Engineering Students Securing more than 80% Securing between 60-80% Medical Students Securing more than 80% Securing between 60-80% Arts Students Securing more than 80% Securing between 60-80%	 30 30 30 30 30 30
2.	Parents (at least Graduate)	15
3.	Experts from Managements	05
	Total	200

TABLE IX. COMPARISON OF THE OUTPUTS RECEIVED FROM THE EXPERTS AND FROM THE SYSTEM

Quality of Performance of teacher	System (Observed O_i)	Expert (Expected E_i)	$(O_i-E_i)^2/E_i$
Low	27	33	1.090909
More or less Low	39	42	0.214286
Medium	62	68	0.529412
More or less High	40	31	2.612903
High	32	26	1.384615
Total			$\chi^2 = 5.832125$

Conclusion

The conclusion of this research is that the output suggested by the system is homogeneous to experts' predictions with respect to the quality of performance of an academician. Since, the system has been tested rigorously and the predictions are consistent with those supplied by experts, it can be concluded that the system is operating similarly to the intelligent behavior of the experts. This allows us to have confidence that the system is capable of providing assistance to the various stake holders in determining the appropriate quality of an academician. An interesting observation coming from this research is that, many a times the quality of teacher is judged from different perspective using different parameters such as academician's research contribution, consultancy etc. In this research we use parameters from the student's point of view. A teacher can be a good researcher but if he can impart knowledge to the students properly, is questionable. This system provides a "second opinion" type of service for the stake holders who use it and thus, will be able to find the quality of the education that is being imparted to the students and efforts can be made in the right direction to improve the education system as a whole. The immense potential of soft computing techniques persuades us that FL can prove to be very promising in designing decision support systems in evaluating the teachers as well. A simplified GUI helps to make this system convenient and user friendly. Interested researchers may request the authors for the source code of the software.

References

[1] Akbulut, Y., & Cardak, C. S. (2012). Adaptive educational hypermedia accommodating learning styles: A content analysis of publications from 2000 to 2011. Computers & Education, 58(2), 835-842.

[2] Alderman, G. L., & Nix, M. (1997). Teachers' intervention preferences related to explanations for behavior problems, severity of the problem, and teacher experience. Behavioral Disorders, 87-95.

[3] Allahverdi, N. (2002). Expert Systems. An Artificial Intelligence Application.Istanbul: Atlas, 248.

[4] Amin, H. U., & Khan, A. R. (2009). Acquiring Knowledge for Evaluation of Teachers Performance in Higher Education using a Questionnaire. arXiv preprint arXiv:0906.4663.

[5] Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. Teaching and teacher education, 27(1), 10-20.

[6] Bai, S. M., & Chen, S. M. (2008). Automatically constructing grade membership functions of fuzzy rules for students' evaluation. Expert Systems with Applications, 35(3), 1408-1414.

[7] Bellman, R. E., & Zadeh, L. A. (1977). Local and fuzzy logics (pp. 103-165). Springer Netherlands.

[8] Berliner, D. C. (2004). Describing the behavior and documenting the accomplishments of expert teachers. Bulletin of Science, Technology & Society, 24(3), 200-212.

[9] Cotton, K. (2000). The Schooling Practices That Matter Most.

[10] Danielson, C. (2013). The Framework for Teaching: Evaluation instrument. Princeton, NJ: The Danielson Group. Retrieved July 8, 2013.

[11] Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in Teacher Preparation How Well Do Different Pathways Prepare Teachers to Teach?.Journal of teacher education, 53(4), 286-302.

[12] Day, C. (1999). Developing teachers: The challenges of lifelong learning. Psychology Press.

[13] Day, C. (2004). A passion for teaching. Routledge.

[14] Dolezal, S. E., Welsh, L. M., Pressley, M., & Vincent, M. M. (2003). How nine third-grade teachers motivate student academic engagement. The Elementary School Journal, 239-267.

[15] Dubois, D., Lang, J., & Prade, H. (1991). Fuzzy sets in approximate reasoning, part 2: logical approaches. Fuzzy sets and systems, 40(1), 203-244.

[16] Fullan, M., & Hargreaves, A. (1996). What's Worth Fighting for in Your School? Revised Edition. Teachers College Press, 1234 Amsterdam Avenue, New York, NY 10027.

[17] Grigoriadou, M., Kornilakis, H., Papanikolaou, K. A., & Magoulas, G. D. (2002). Fuzzy inference for student diagnosis in adaptive educational hypermedia. InMethods and applications of artificial intelligence (pp. 191-202). Springer Berlin Heidelberg.

[18] Hanushek, E. A., & Rivkin, S. G. (2006). Teacher quality. Handbook of the Economics of Education, 2, 1051-1078.

[19] Hutchings, M., Menter, I., Ross, A., Thomson, D., & Bedford, D. (2000).Teacher Supply and Retention in London 1998-99: A study of six London boroughs. London: Teacher Training Agency.

[20] Ingvarson, L., & Rowe, K. (2008). Conceptualising and evaluating teacher quality: Substantive and methodological issues. Australian Journal of Education, 52(1), 5-35.

[21] Kauchak, D. P., & Eggen, P. D. (1993). Learning and teaching (2nd ed.). Boston, MA: Allyn and Bacon.

[22] Kington, A., Sammons, P., Day, C., & Regan, E. (2011). Stories and statistics: Describing a mixed methods study of effective classroom practice. Journal of Mixed Methods Research, 5(2), 103-125.

[23] Ko, J., & Sammons, P. (2013). Effective Teaching: A Review of Research and Evidence. CfBT Education Trust. 60 Queens Road, Reading, RG1 4BS, England.

[24] Kyriakides, L., Creemers, B. P., & Antoniou, P. (2009). Teacher behaviour and student outcomes: Suggestions for research on teacher training and professional development. Teaching and Teacher Education, 25(1), 12-23.

[25] Li, X. (2007). Intelligent Agent–Supported Online Education. Decision Sciences Journal of Innovative Education, 5(2), 311-331.

[26] Mamdani, E. H. (1974, December). Application of fuzzy algorithms for control of simple dynamic plant. In Proceedings of the Institution of Electrical Engineers (Vol. 121, No. 12, pp. 1585-1588). IET Digital Library.

[27] Marzano, R. J. (2003). What works in schools: Translating research into action. ASCD.

[28] Maulana, R., Helms-Lorenz, M., & van de Grift, W. (2015a). Pupils' perceptions of teaching behaviour: Evaluation of an instrument and importance for academic motivation in Indonesian secondary education. International Journal of Educational Research, 69, 98-112.

[29] Maulana, R., Helms-Lorenz, M., & van de Grift, W. (2015b). A longitudinal study of induction on the acceleration of growth in teaching quality of beginning teachers through the eyes of their students. Teaching and Teacher Education,51, 225-245.

[30] Maulana, R., Opdenakker, M. C., Stroet, K., & Bosker, R. (2012). Observed lesson structure during the first year of secondary education: Exploration of change and link with academic engagement. Teaching and Teacher Education,28(6), 835-850.

[31] Maulana, R., Opdenakker, M. C., Stroet, K., & Bosker, R. (2013). Changes in teachers' involvement versus rejection and links with academic motivation during the first year of secondary education: A multilevel growth curve analysis.Journal of youth and adolescence, 42(9), 1348-1371.

[32] Opdenakker, M. C., & Minnaert, A. (2011). Relationship between learning environment characteristics and academic engagement 1. Psychological Reports, 109(1), 259-284.

[33] Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. Educational Researcher, 38(2), 109-119.

[34] Rice, J. K. (2003). Teacher quality: Understanding the effectiveness of teacher attributes. Economic Policy Institute, 1660 L Street, NW, Suite 1200, Washington, DC 20035.

[35] Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. Econometrica, 417-458.

[36] Rockoff, J. E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. American Economic Review, 247-252.

[37] Rosenholtz, S. (1989). Teachers' Workplace: The Social Organization of Schools (New York, Teachers College Record).

[38] Ross, T. J., Booker, J. M., & Parkinson, W. J. (Eds.). (2002). Fuzzy logic and probability applications: bridging the gap (Vol. 11). SIAM.

[39] Rowan, B., Correnti, R., & Miller, R. (2002). What Large-Scale Survey Research Tells Us About Teacher Effects on Student Achievement: Insights from the Prospects Study of Elementary Schools. The Teachers College Record, 104(8), 1525-1567.

[40] Saaty, T. L. (2000). Fundamentals of decision making and priority theory with the analytic hierarchy process (Vol. 6). Rws Publications.

[41] Saleh, I., & Kim, S. I. (2009). A fuzzy system for evaluating students' learning achievement. Expert Systems with Applications, 36(3), 6236-6243.

[42] Sanders, W. L., Wright, S. P., & Horn, S. P. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. Journal of personnel evaluation in education, 11(1), 57-67.

[43] Schroeder, C. M., Scott, T. P., Tolson, H., Huang, T. Y., & Lee, Y. H. (2007). A meta- analysis of national research: Effects of teaching strategies on student achievement in science in the United States. Journal of Research in Science Teaching, 44(10), 1436-1460.

[44] Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform.Harvard educational review, 57(1), 1-23.

[45] Siler, W., & Buckley, J. J. (2005). Fuzzy expert systems and fuzzy reasoning. John Wiley & Sons.

[46] Stronge, J. H., Ward, T. J., Tucker, P. D., & Hindman, J. L. (2007). What is the relationship between teacher quality and student achievement? An exploratory study. Journal of Personnel Evaluation in Education, 20(3-4), 165-184.

[47] The Mathworks, http://www.mathworks.com.

[48] Troman, G., & Woods, P. (2001). Primary teachers' stress. Psychology Press.

[49] Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. Review of educational research, 68(2), 202-248.

[50] Van de Grift, W. (2007). Quality of teaching in four European countries: a review of the literature and application of an assessment instrument.Educational research, 49(2), 127-152.

[51] Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning.Teaching and teacher education, 24(1), 80-91.

[52] Wang, M. C. (1995). Serving students at the margins. Educational Leadership,52(4), 12-17.

[53] Wang, X. (2000). A comparative study on effective instructional practices and ineffective instructional practices. Theory and Practice of Education, 20(9), 50-53.

[54] Yair, G. (2000). Educational battlefields in America: The tug-of-war over students' engagement with instruction. Sociology of Education, 247-269.

[55] Yen, J., & Langari, R. (1998). Fuzzy logic: intelligence, control, and information. Prentice-Hall, Inc..

[56] Zadeh, L. A. (1965). Fuzzy sets. Information and control, 8(3), 338-353.