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APPLICATION OF FUZZY ANALYTICAL HIERARCHY PROCESS (FAHP) FOR TEACHING QUALITY EVALUATION AT DEFENCE FOUNDATION CENTRE

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ABSTRACT

Academic staff is one of the backbones of any educational institution and is responsible for the quality of students produced. Assessment of quality teaching has always been an endless debate within institutions. Research towards better teaching assessment on various criteria has been proposed. In past studies, teaching performance of academic staff was mostly evaluated based on only single numerical value, i.e. rating. Various studies have suggested different criteria on how to assess teaching performance. Due to the subjective nature of the students' evaluation, the single rating, i.e. 1 to 5 score (very low to very high, respectively) achieved by academic staff are very general and lack accuracy. This research paper will venture into the teaching evaluation using Fuzzy Analytical Hierarchy Process (Fuzzy AHP) from the perspective of subject experts. The study will incorporate three main criteria for evaluating teaching quality, i.e. staff personal traits, knowledge transfer, and knowledge evaluation. It is found that speech culture (0.149) is deemed as the priority among other teaching quality criteria assessed.

Introduction

Often in our everyday life, we come across a situation where we could not decide whether the statement is true or false. For example, when we speak about "high payment" of a salary, the "excellent team" of an organisation, "good result" achieved by students in college and so forth, it can be sought that such scenarios have no boundaries. The same situation happens in evaluating lecturers' teaching performance. As a standardised psychometric scale, the classical technique using the Likert method is widely implemented to calculate responses encoded by integers. i.e., 1 to 5 (1-very low; 2-low; 3-moderate; 4-high; 5-very high). The evaluation of teaching quality of academic staff in any institution by students involves uncertainties and ambiguities. Students may favour lecturers with specific personal traits preferred rather than justifying knowledge, professionalism and other characteristics. Therefore, those unfavourable lecturers may elicit poor performance feedback from their students and hence directly link to students' achievement. Due to that, fuzzy sets theory introduced by Zadeh (1975) offers precious flexibility for reasoning. Fuzzy approaches students to deal better with any ambiguous evaluation of teaching performance of lecturers whenever they are unsure (as it may frequently happen) of a numerical scale representing teaching performance of academic staff [1]. It is therefore essential to measure the teaching performance using mathematical representation in such circumstances. Student assessment of teaching quality is one of the main methods for enhancing the teaching quality and plays a crucial role in reinforcing the development of higher learning institutions. However, the initial objective of this study is to explore the use of the fuzzy approach in evaluating teaching quality in university from the perspective of subject experts, i.e. lecturers and university administrators.

According to Vevere & Kozlinskis (2011), students' assessments of teaching content are one of the main aspects of determining the quality of academic staff teaching [2]. Several authors agree this that the evaluation of teaching quality is deemed reliable from students' feedback [2-5]. This happens even though some argued that the feedbacks from students might be biased or prejudiced due to its subjectivity nature. The teaching quality of academic staff can be seen in various aspects including knowledge level and personality to name a few [2, 4-5]. Recent studies have shown that many researchers and practitioners prefer methods of giving variability of answers while capturing subjectivity for evaluating teaching performance. As Moayeri et al. (2016) stated, in contrast to other methodologies, the results have shown that the Fuzzy AHP methodology has been commonly utilised in decision making [5]. The model construction of the teaching quality assessment scheme on the practical teaching experiment of teachers illustrates teachers' current teaching dynamics. In addition, on the basis of the experimental teaching reform and growth law of laboratory construction, it has a similar influence, essentially representing the assessment of teacher's teaching. It also indicates the aim of fostering the artistic consciousness and functional capacity of students. This study is outlined as follows: Section 2 represents the research works on teaching evaluations and a brief description of criteria and sub-criteria used in this study. Section 3 explains the fuzzy technique process, while section 4 highlights the teaching evaluation criteria using the fuzzy approach with an illustrative example. In section 5 reports the conclusion and suggest future works.

Research works on teaching evaluations

Most institutions and organisations use teaching performance appraisal system to evaluate its members' performance. The academic staff teaching quality is essential to the students and as well as the institution's management. The primary function of teaching evaluation is to carry out information feedback, which can promote the quality of students' learning and the lecturing level of academic staff. The normally used ratings in teaching evaluation typically involve crisp and uncertain values. There are abundant of studies on the implementation of the approach in teaching evaluations and performance that focuses on the classical method where scales and index numbers were used. Thus, the uncertainties in decision making may encounter evaluation flaws. However, the recent trend in teaching performance discovered by researchers and managers found that soft computing is most demanding and well-known in the evaluation of teaching performance.

Teaching qualities

The description of the mentioned components adopted from Vevere (2011) is portrayed in Table 1 [5].

Table 1: Criteria and Sub-criteria of Teaching Quality

Personal traits (C1)		
No	**Attribute**	**Description**
S1	Speech culture	A basis for the development of general human culture and a central concept of the new linguistic discipline together with corresponding requirements to the usage of linguistic means [6]
S2	Respect for the student	Communicating respect and care for students
S3	Appropriate appearance	Presentable and adhere to the dress code at work
S4	Responsiveness	Linguistically and culturally responsive teacher who is committed to serve students and create caring classrooms
S5	Punctuality	Ability to work promptly and deliver the subject according to the stipulated time [7]
S6	Good manners	Teacher's role in fostering the moral and intellectual development of the students. In this situation, the manner is characterised as the

Personal traits (C1)		
No	**Attribute**	**Description**
		expressive behaviour of the dispositions or characteristics of a character that comes within an excellent moral category better known as virtue
S7	Ability to control and discipline students	Capable of dealing with classroom management and discipline problems. Discipline is the outcome of cleverly designed treatment of classroom disturbances in the instructional sense [8]
Knowledge transfer (C2)		
S8	Supply with adequate workloads)	The workload is characterised as the connection between the resources needed to perform a task and the available resources, and hence supplied by the teacher desirably [9]
S9	Oppose different theories	Simply to oppose the different theories against one another would be quite mistaken. This component refers to an attempt to determine which particular context of different theories are applicable as the proposed theories may not possess universal validity
S10	Ask students about their goals	Inquire students about what they want to achieve
S11	Introduce topic appropriately	Teaching a particular topic with a decent beginning
S12	Ask students about their learning interests	Inquire students about their interest in learning
S13	Encourage students to focus on their interests and goals	Motivate students to concentrate on their interest and work in line with the goals they aim to achieve
S14	Provide with appropriate practical example	Able to come out with an appropriate or suitable example for actual use
S15	Explore learning issues fully	Ensure students to be aware with the learning issues comprehensively
S16	Ensure the required supply of literature and handout materials	Provide sufficient supply of teaching materials
S17	Offer different viewpoints to the subject	Establish a class atmosphere where the perspectives of learning and expertise of students will grow. The variability of definition will channel the lower learners through higher-level thought. On the other hand, they will adapt guidance for higher learners to help them evolve [10]
S18	Inspire students for further reading	Encourage students to read further for more information or better understanding. Instil the reading culture regardless of age and profession. Spoon-feeding is not encouraged
Knowledge evaluation (C3)		
S19	Offer students to evaluate themselves	Give opportunity for students to appraise themselves
S20	Ask students how they intend to achieve the goals and tasks set	Seek information on how students plan to achieve their goals and tasks set
S21	Offer students to share their ideas and knowledge	Provide knowledge sharing sessions and discussions
S22	Explain to students why they were right or wrong	*It is best applied by explaining* how students could have come up with the *right* answer or solution [11]
S23	Open new learning opportunities	Expose students to learning opportunities from the classroom into the real world

Research works on teaching evaluation using fuzzy technique

This section discusses the numerous research on teaching assessment using fuzzy logic technique. One of the profound studies is conducted by Rashid et al. (2011) who addressed the practical of adopting expert system using fuzzy logic criteria for assessing educator's performance [12]. They developed the tool of knowledge acquisition for educator' assessment problem in developing intelligent expert system by extracting 99 attributes from existing studies and categorised them into 15 groups.

Later in 2012, Pavani et al., in their article "Evaluation of teacher's performance using fuzzy logic technique" proposed for students' feedback assistance to apply the inputs and outputs of fuzzy logic in performance evaluation of a teacher [13]. The five fuzzy inputs such as knowledge, delivery speed, presentation, overall impression and explanation are required for assessment; along with performance as one of the outputs. In this analysis, the Fuzzy Inference System (FIS) established numerous input parameters to determine the educator's output using two membership functions: triangular and trapezoidal, and performance comparison. Further, Bhosale (2013) built a fuzzy inference method employing MATLAB for the performance evaluation of lecturers [14]. In aggregating the grades from all categories and in generating a final ranking, the model can be used as an alternative. In terms of input parameters for fuzzification, the factors employed for measuring the performance are described. The research uses the fuzzy inference method to contend with the explosion of the rule problem. He indicated that, upon using Mamdani-type inference, the fuzzy inference method could be introduced. The centre of gravity approach is chosen for the defuzzification of the resulting fuzzy set. The study can be expanded by evaluating the remaining categories for measuring the performance of teachers that can be used for judgmental and developmental reasons to make better administrative decisions in the field of higher education.

Version et al., (2014) also suggested an optimised online interactive performance evaluation framework for faculty that offers appropriate evaluations to promote professional development and progress [15]. The mechanism is intended to encourage the advancement of teachers and, when necessary, recognise resources for increased support. The implementation involves the incorporation of preparation and analysis of the fields of measurement of the individual performance of an academic institution, student reviews, teacher's self-assessment, peer assessment and university exam results. A standardised online interactive interface is given that contains possible associated faculty data evaluation. The success evaluation process reflects one of the aspects of maintaining a high level of students' achievement by enabling teachers to reach their maximum potential. Apart from that, for effective managerial decisions, Kamath (2014) suggested a model that can be followed for the assessment of teacher results [16]. The use of fuzzy set theory in evaluation systems will increase the accuracy of the outcomes of the evaluation. This model will produce critical frameworks for success appraisal and appropriate help in decision-making. This model will provide a substantial success basis for practices related to instruction, learning and assessment, co-curricular, expansion, career establishment, research, publications, and scholarly contributions. The research applied many inputs with a single output. The centre of gravity approach for defuzzification is utilised in this model. While the literature has proposed multiple assessment approaches for choosing or rating, to date, there is no ideal approach that can offer adequate solutions to different scenarios. Reassuring the quality of teaching is a concern of higher learning institutions, especially in the public sector. Higher learning institutions ought to include an authentic and substantial framework to assess a lecturer's performance in order to accomplish this aim. The assessment of the quality of teaching in practise relies on several aspects and parameters. The Institute of Higher Learning needs to identify different indicators and qualities that are important for assessment in ensuring an effective teaching.

The lack of knowledge and a collection of assessment criteria for the end outcome is one of the disadvantages of the conventional department/faculty evaluation processes. In doing that, a fuzzy methodology was utilised to carry out the suggested method of total teaching assessment results. It is essential to emphasise that the purpose of the proposed approach is not to eliminate the existing traditional assessment method, but merely to reinforce the current framework by offering more alternatives and knowledge to be used by computerisation for consumer decision-making. This study explored the soft computing framework employing fuzzy set theory for evaluating lecturers' teaching qualities from the perspective of subject experts. Since the level of agreement rated by each expert on the teaching quality is subjective and the statements described the standard cannot be described as 'yes' or 'no' and 'true' or 'false' (as found in classical theory), the rating of the statements are made based on a number of options of not important, slightly important, moderately important, important, and very important. By comparison, statements can have values in the range of (0, 1) in a fuzzy set theory approach. This subjective approach and measurement parameters that quantify the ambiguous context are meant to change the environment and give more choices to interpret. Thus, the implementation of fuzzy set theory is an efficient way of formulating a decision problem (meaning in vague) where arbitrary and imprecise inputs are available.

Preliminaries

This section presents the basic ideas used in this analysis.

Fuzzy sets and Fuzzy number set

Fuzzy Set Theory (FST) was introduced by Zadeh (1975) [1]. It can be applied to deal with uncertainty due to imprecision and vagueness. The application of FST to solve many uncertainties in real-world problems has been recognised since its first introduction. The definition of FST is shown in Definition 1 below.

Definition 1.

Let X be the universe of discourse, $\breve{A}$ is a fuzzy subset of X such that for all $x \in X$, $\mu_{\breve{A}}(x) \in [0,1]$, which is called the membership degree (grade) of x in $\breve{A}$, to which x verifies the characteristic property of the set $\breve{A}$. The nearer the value $\mu_{\breve{A}}(x)$ to 1, the higher the membership degree of x in $\breve{A}$. Imprecisely, fuzzy sets define continuous membership grades that vary from zero to one. If the value assigned is zero, the element does not adhere to the set, and if the value assigned is one, the element belongs to the set entirely. Finally, the value lying between zero and one belongs only to the fuzzy set.

Triangular and trapezoidal fuzzy number (TFN) sets are the commonly used fuzzy number sets. A trapezoidal fuzzy number can be a triangular fuzzy number if the two promising values of the trapezoidal fuzzy number are the same. In other words, triangular is a special case of a trapezoidal fuzzy number. Due to its intuitive applied and analytical computational efficiency, the triangular fuzzy number is a more favourable fuzzy number used in numerous applications. Triangular and trapezoidal fuzzy number is generally employed to deal with the vagueness of the parameters exits in the DM process. Thus, TFNs is expressed in a range form instead of crisp numbers. The definition and its arithmetic equalities are given below.

Definition 2.

A triangular fuzzy number $\breve{A}$ is represented as $\breve{M} = (l, m, u)$ and its MF is described as in Eqn. (1).

$$\mu_{\breve{M}}(x) = \begin{cases} 0 & , x < l \\ \dfrac{x - l}{m - l} & , l \le x \le m \\ \dfrac{\mu - x}{\mu - m} & , m \le x \le \mu \\ 1 & , x > \mu \end{cases} \tag{1}$$

The parameters l, m, μ indicate the smallest possible value, the most promising value, and the largest possible value, respectively, that describes the fuzzy event [5]. Let $\widetilde{M_1} = (l_1, m_1, \mu_1)$ and $\widetilde{M_2} = (l_2, m_2, \mu_2)$. The basic operations that can be performed on TFNs are as follows,

Addition/subtraction $\quad (l_1 \pm l_2, m_1 \pm m_2, \mu_1 \pm \mu_2)$

Multiplication $\quad (l_1 \times l_2, m_1 \pm \times, \mu_1 \times \mu_2)$

Division $\quad \widetilde{M_1}^{-1} = (\frac{1}{\mu_1}, \frac{1}{m_1}, \frac{1}{l_1})$

Assessment Model

Chang's extent analysis method on Fuzzy AHP are summarised below [17]:

Let $U = \{u_1, u_2, u_3, \dots, u_m\}$ be a goal set and $X = \{x_1, x_2, \dots, x_n\}$ be the object set. Each object is taken, and the extent analysis for every goal performed. Therefore, m extent analysis values for each goal can be obtained, with the following signs:

$$\breve{M}_{gi}^1, \breve{M}_{gi}^2, \breve{M}_{gi}^3, \dots, \breve{M}_{gi}^m, \qquad i = 1, 2, \dots, n,$$

where all $\boldsymbol{\breve{M}_{gi}^j}$ $(\boldsymbol{j = 1, 2, 3, \dots, m})$ are triangular fuzzy number sets and $\boldsymbol{g_i}$ is the corresponding goal. The value of fuzzy synthetic extent with respect to $\boldsymbol{i}^{\text{th}}$ object is defined as,

$$S_i = \sum_{j=1}^{m} \breve{M}_{gi}^j \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \breve{M}_{gi}^j \right]^{-1}.$$

To obtain $\sum_{j=1}^{m} \breve{M}_{gi}^j$, the fuzzy addition operation of m extent analysis is performed as

$$\sum_{j=1}^{m} \breve{M}_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} \mu_j \right).$$

In order to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \breve{M}_{gi}^j\right]^{-1}$, the fuzzy addition operation of $\breve{M}_{gi}^j$ $(j = 1, 2, 3, \dots, m)$ values are carried out as

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \breve{M}_{gi}^j = (\sum_{i-1}^{n} l_i, \sum_{i-1}^{n} m_i, \sum_{i-1}^{n} \mu_i)$$

and the inverse of the vector is computed such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \breve{M}_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i-1}^{n} \mu_i}, \frac{1}{\sum_{i-1}^{n} m_i}, \frac{1}{\sum_{i-1}^{n} l_i} \right).$$

The degree of possibility

$$\widetilde{M_2} = (l_2, m_2, \mu_2) \geq \widetilde{M_1} = (l_1, m_1, \mu_1)$$

is defined as

$$V(\widetilde{M_2} \geq \widetilde{M_1}) = \sup_{y \geq x} \left[min\left(\mu_{\widetilde{M_1}}(x), \mu_{\widetilde{M_2}}(y)\right) \right]$$

and it can be expressed as follows,

$$V = (\widetilde{M_2} \geq \widetilde{M_1}) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ \iota_1 \geq \mu_2 \\ \dfrac{l_1 - \mu_2}{(m_2 - \mu_2) - (m_1 - l_1)}, & otherwise \end{cases}.$$

The degree of possibility for a convex fuzzy number to be greater then k convex fuzzy number set. $\widetilde{M_\iota}$ $(i = 1, 2, 3, \dots, k)$ can be defined by $V(\breve{M} \geq \widetilde{M_1}, \widetilde{M_2}, \widetilde{M_3}, \dots, \widetilde{M_k}) = \min V(\breve{M} \geq \widetilde{M_\iota})$. Assume that

$$d'(A_i) = \min V(S_i \geq S_k)$$

for $k = 1, 2, \dots, n$ and $k \neq i$, the weight vector is given by

$$W'(A_i) = [d'(A_1), d'(A_2), d'(A_3), \dots, d'(A_n)]^T$$

where $A_i (i = 1, 2, 3, \dots, n)$ are n elements. Via normalisation, the normalised weight vectors are

$$W = [d(A_1), d(A_2), d(A_3), \dots, d(A_n)]^T.$$

The following are five (5) steps involved in the proposed framework for designing lecturer's evaluation index system.

Step 1 **Develop the hierarchical structure of the evaluation index system**

By integrating all the requirements and sub-criteria relevant to the research issue, the framework is built. Relying on the specified criteria extracted from [2], the hierarchical structure is shown in Fig. 1.

Step 2 **Determining the linguistic variable and fuzzy conversion scale**

To define the relative value of factors and sub-factors, linguistic variables are added. It is a vector of words or sentences in a natural or artificial language [1]. In the form of linguistic variables, the piecewise comparison of one element to another can be performed using questionnaires. Linguistic variables can be transformed into fuzzy scales to continue with statistical operations. In the AHP approach, the piecewise comparison is made using a nine-point ratio scale. In this study, TFNs proposed by Kahraman et al., (2003) are used to represent fuzzy piecewise comparisons and convert linguistic variables into fuzzy scales [18]. The triangular fuzzy number set scales are displayed in Table 2.

Table 2: TFNs

Fuzzy number	Linguistic scale	Membership function	Inverse
1	Equally important	(1, 1, 1)	(1, 1, 1)
3	Moderately important	(1, 3/2, 2)	(1/2, 2/3, 1)
5	More important	(3/2, 2, 5/2)	(2/5, ½, 2/3)
7	Strongly important	(2, 5/2, 3)	(1/3, 2/5, 1/2)
9	Extremely important	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)

Step 3 **Establishing comparison matrices**

After building the hierarchical structure that involves dimensions and sub-dimensions, the relative value of two judgement components at the same level would be delegated to experts. If the experts have obtained pairwise comparative ratings, the next step is to form a comparison matrix for each decision-maker. Pairwise comparison matrices are constructed to transfer the linguistic variable into TFNs,

$$\breve{A} = (\widetilde{a_{ij}})_{m\times n} = \begin{bmatrix} 1 & \widetilde{a_{12}} & \widetilde{a_{1n}} \\ \widetilde{a_{21}} & 1 & \widetilde{a_{2n}} \\ & & \\ \widetilde{a_{n1}} & \widetilde{a_{n2}} & 1 \end{bmatrix},$$

where $\widetilde{a_{ij}}$ is a triangular fuzzy number after comparing factor i to factor j while $[\widetilde{a_{ij}}]^{-1}$ is the TFNs comparing factor j to factor i. Also, $\widetilde{a_{ij}}$ and $[\widetilde{a_{ij}}]^{-1}$ can be denoted as:

$$\widetilde{a_{ij}} = (l_{ij}, m_{ij}, u_{ij}) = [\widetilde{a_{ij}}]^{-1} = (u_{ij}^{-1}, m_{ij}^{-1}, l_{ij}^{-1})$$

Step 4 **Consistency Index**

In order to ensure that the DM decision is accurate and to prevent any deceptive solutions, accuracy needs to be evaluated. The soft contrast matrices must be transformed into crisp matrices to achieve accuracy. To generate a crisp number from TFN, there are many methods of defuzzification that can be used. The technique suggested by Chang (1996) in this analysis is utilised to defuzzify the TFNs [17]. This method expresses the fuzzy perception as the preference (α) and risk tolerance (λ) of DMs. Under various situations, DMs can consider the uncertainties they face. A TFN defined as $\widetilde{a_{ij}} = (l_{ij}, m_{ij}, u_{ij})$ may be defuzzified to a crisp number as follows:

$$(a_{ij}^{\alpha})^{\lambda} = [\lambda \cdot l_{ij}^{\alpha} + (1-\lambda)u_{ij}^{\alpha}], \qquad 0 \le \lambda \le 1, \qquad 0 \le \alpha \le 1,$$

where $l_{ij}^{\alpha} = (m_{ij} - l_{ij}) \times \alpha + l_{ij}$ denotes the left end value of α cut for α_{ij}, while $u_{ij}^{\alpha} = u_{ij} - (u_{ij} - m_{ij}) \times \alpha$- right end value. In FAHP, testing the consistency of decision-makers is necessary and to achieve that, the priority of elements of decision-makers will be contrasted via calculating eigenvalues and eigenvectors, given by

$$RW = \lambda_{max}$$

where W refers to the eigenvector, usually denoted as the weight vector of the matrix. Consistency is then tested to certify that decisions are consistent. The consistency ratio was established by Saaty (1988), and the consistency index may be written as CI and CR.

$$CI = \frac{\lambda_{max} - n}{n-1}$$

and

$$R = \frac{CI}{RI}$$

where *n* denotes the total number of elements being compared while *RI* is the random index. Matrices of equal size can be contrasted randomly to produce an arbitrary index. If the ratio of accuracy is greater than 0.10, the decision-maker (expert) must check the original values.

Step 5 **Establishing the matrix representative of all decision-makers**

During positive matrices construction process, linguistic variables will be generated by modifying pairwise comparison ratings, while TFNs will interpret these variables [19]. Fuzzy weights will be evaluated based on Lambda-Max method [20]. In this stage, the viewpoints of decision-makers will be implemented. The geometric mean is then implemented to integrate fuzzy weights of the decision-makers. The last stage is to achieve the decision-makers' final ranking, and this will be accomplished by the following suggested equation in [21].

Numerical illustration

The purpose of the teaching assessment is to provide lecturers with details and input to increase the quality of teaching. The present paper is aimed at finding the characteristics of teaching quality necessary for a lecturer to have and the criteria of teaching quality assessed based on academic staff personal traits, knowledge transfer and knowledge evaluation (Fig. 1). Five randomly high qualified and well-experienced experts from the foundation centre at NDUM (National Defence University of Malaysia) were chosen, consisting of lecturers and academic administrator [22]. Questionnaires were distributed and the experts were simply asked to indicate how important they thought each item was with regard to lecturer characteristics. They were also being asked about various factors that affected the quality of teaching and were required to rank these criteria. The initial results and priority assigned to those criteria are shown in Table 5. The research questionnaire has 23 items to assess teaching quality of academic staff based on a nine-point Likert scale.

A method is provided in this paper to test teaching efficiency based on fuzzy AHP. Firstly, the index system has been defined, and then the sub-factors' factor and weight are measured using the fuzzy AHP process. In making community decisions, the use of fuzzy AHP emphasises the consensus of five decision-makers and eliminates uncertainty. Subsequently, to rate the teaching content assessment criteria, Fuzzy evaluation is then employed. This study also employs case applications to demonstrate the suggested structure (as shown in Fig. 1) where scientific and objective assessment findings can be obtained from the execution of it [23-24].

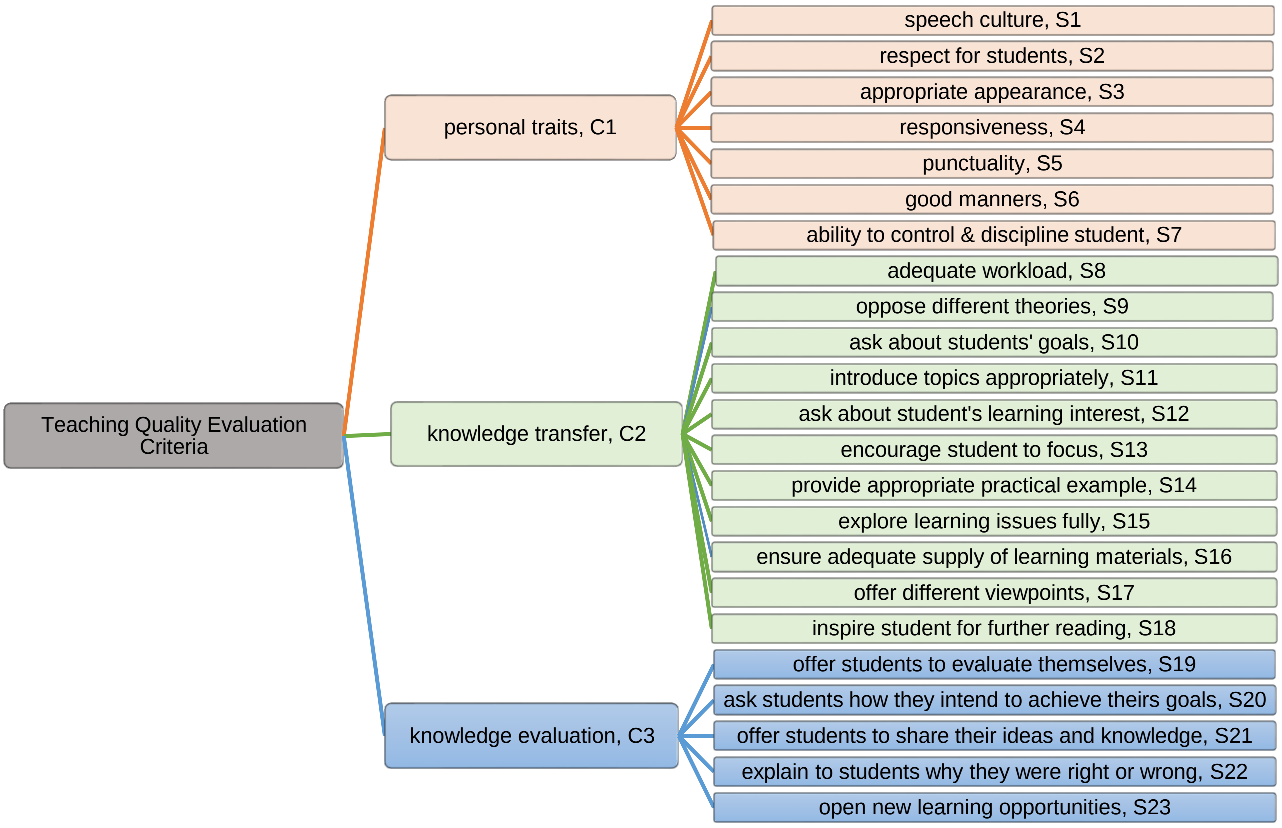

Fig. 1: Hierarchical structure of this research problem proposed [2]

By integrating all the factors (C) and sub-factors (S) unique to the research problem, the hierarchical structure is constructed. The hierarchical structure for assessment is obtained based on the factors and sub-factors defined. The target in the method is at the first level, and variables and sub-factors are at successive stages.

Table 3: Fuzzy comparison matric of criteria with respect to the overall objective

	C1 **Personal traits**	C2 **Knowledge transfer**	C3 **Knowledge evaluation**
C1	(1, 1, 1)	(1, 2.93, 5)	(1, 3.95, 9)
C2	(0.2, 0.34, 1)	(1, 1, 1)	(1, 1.9, 4)
C3	(0.11, 0.25, 1)	(0.25, 0.52, 1)	(1, 1, 1)

[CI:0.015, CR:0.049]

The different sub-criteria are compared under each of the criteria separately by following the same procedure as discussed above.

Table 4a: Fuzzy comparison matrix of the sub-criteria with respect to staff's personal traits

C1	S1	S2	S3	S4	S5	S6	S7
S1	(1, 1, 1)	(1.000,1.889,4.000)	(1.000,3.650,7.000)	(2.000,4.705,9.000)	(3.000,5.144,7.000)	(4.000,6.494,9.000)	(7.000,8.001,9.000)
S2	(0.250,0.529,1.000)	(1, 1, 1)	(1.000,1.516,3.000)	(2.000,3.447,7.000)	(2.000,3.899,6.000)	(4.000,5.185,7.000)	(4.000,5.698,9.000)
S3	(0.143,0.274,1.000)	(0.333,0.660,1.000)	(1, 1, 1)	(1.000,1.644,4.000)	(1.000,2.767,4.000)	(2.000,3.898,6.000)	(2.000,5.104,9.000)
S4	(0.111,0.213,0.500)	(0.143,0.290,0.500)	(0.250,0.608,1.000)	(1, 1, 1)	(1.000,1.320,3.000)	(1.000,2.760,6.000)	(1.000,3.367,7.000)
S5	(0.143,0.194,0.333)	(0.167,0.256,0.500)	(0.250,0.361,1.000)	(0.333,0.758,1.000)	(1, 1, 1)	(1.000,1.741,3.000)	(1.000,2.551,4.000)
S6	(0.111,0.154,0.250)	(0.143,0.193,0.250)	(0.167,0.257,0.500)	(0.167,0.362,1.000)	(0.333,0.574,1.000)	(1, 1, 1)	(1.000,1.149,3.000)
S7	(0.111,0.125,0.143)	(0.111,0.176,0.250)	(0.111,0.196,0.500)	(0.143,0.297,1.000)	(0.250,0.392,1.000)	(0.333,0.870,1.000)	(1, 1, 1)

[CI:0.015, CR:0.038]

Table 4b: Fuzzy comparison matrix of the sub-criteria with respect to knowledge transfer

C2	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
S8	(1, 1, 1)	(1.000,2.170,4.000)	(1.000,2.493,5.000)	(1.000,2.268,6.000)	(1.000,2.491,5.000)	(2.000,4.044,7.000)	(1.000,3.393,6.000)	(1.000,4.805,9.000)	(2.000,5.651,9.000)	(1.000,4.283,9.000)	(1.000,5.522,9.000)
S9	(0.250,0.461,1.000)	(1, 1, 1)	(1.000,1.320,3.000)	(1.000,2.048,4.000)	(1.000,2.268,6.000)	(1.000,2.352,4.000)	(1.000,2.352,4.000)	(1.000,2.725,6.000)	(1.000,3.273,6.000)	(1.000,3.129,6.000)	(1.000,4.319,7.000)
S10	(0.200,0.401,1.000)	(0.333,0.758,1.000)	(1, 1, 1)	(1.000,1.516,3.000)	(1.000,1.644,4.000)	(1.000,1.741,3.000)	(1.000,2.048,4.000)	(2.000,3.000,4.000)	(1.000,3.245,6.000)	(1.000,2.606,6.000)	(1.000,3.129,6.000)
S11	(0.167,0.441,1.000)	(0.250,0.488,1.000)	(0.333,0.660,1.000)	(1, 1, 1)	(1.000,1.149,3.000)	(1.000,1.888,4.000)	(1.000,1.431,4.000)	(1.000,2.221,4.000)	(1.000,2.667,6.000)	(1.000,2.667,6.000)	(1.000,4.164,6.000)
S12	(0.200,0.401,1.000)	(0.167,0.441,1.000)	(0.250,0.608,1.000)	(0.333,0.870,1.000)	(1, 1, 1)	(1.000,1.000,1.000)	(1.000,2.352,4.000)	(1.000,1.644,4.000)	(1.000,1.933,4.000)	(1.000,1.889,5.000)	(1.000,2.955,6.000)
S13	(0.143,0.247,0.500)	(0.250,0.425,1.000)	(0.333,0.574,1.000)	(0.250,0.530,1.000)	(1.000,1.000,1.000)	(1, 1, 1)	(1.000,1.149,3.000)	(1.000,1.644,4.000)	(1.000,2.353,4.000)	(1.000,2.221,4.000)	(1.000,1.933,4.000)
S14	(0.167,0.295,1.000)	(0.250,0.425,1.000)	(0.250,0.488,1.000)	(0.250,0.699,1.000)	(0.250,0.425,1.000)	(0.333,0.870,1.000)	(1, 1, 1)	(1.000,1.516,3.000)	(1.000,1.821,6.000)	(1.000,2.551,4.000)	(1.000,1.888,4.000)
S15	(0.111,0.208,1.000)	(0.167,0.367,1.000)	(0.250,0.333,0.500)	(0.250,0.450,1.000)	(0.250,0.608,1.000)	(0.250,0.608,1.000)	(0.333,0.660,1.000)	(1, 1, 1)	(1.000,1.431,4.000)	(1.000,1.516,3.000)	(1.000,1.741,3.000)
S16	(0.111,0.177,0.500)	(0.167,0.306,1.000)	(0.167,0.308,1.000)	(0.167,0.375,1.000)	(0.250,0.517,1.000)	(0.250,0.425,1.000)	(0.167,0.549,1.000)	(0.250,0.699,1.000)	(1, 1, 1)	(1.000,1.149,3.000)	(1.000,1.149,3.000)
S17	(0.111,0.233,1.000)	(0.167,0.320,1.000)	(0.167,0.384,1.000)	(0.167,0.375,1.000)	(0.200,0.529,1.000)	(0.250,0.450,1.000)	(0.250,0.392,1.000)	(0.333,0.660,1.000)	(0.333,0.870,1.000)	(1, 1, 1)	(1.000,1.320,3.000)
S18	(0.111,0.181,1.000)	(0.143,0.232,1.000)	(0.167,0.320,1.000)	(0.167,0.240,1.000)	(0.167,0.338,1.000)	(0.250,0.517,1.000)	(0.250,0.530,1.000)	(0.333,0.574,1.000)	(0.333,0.870,1.000)	(0.333,0.758,1.000)	(1, 1, 1)

[CI:0.013, CR:0.093]

Table 4c: Fuzzy comparison matrix of the sub-criteria with respect to knowledge evaluation

C3	S19	S20	S21	S22	S23
S19	(1, 1, 1)	(1.000,2.767,7.00)	(1.000,2.627,6.000)	(1.000,3.642,9.000)	(1.000,4.042,7.000)
S20	(0.143,0.361,1.00)	(1, 1, 1)	(1.000,1.320,3.000)	(1.000,1.741,3.000)	(1.000,1.889,5.000)
S21	(0.167,0.381,1.00)	(0.333,0.758,1.00)	(1, 1, 1)	(1.000,1.149,3.000)	(1.000,1.888,4.000)
S22	(0.111,0.275,1.00)	(0.333,0.574,1.00)	(0.333,0.870,1.000)	(1, 1, 1)	(1.000,1.431,4.000)
S23	(0.143,0.247,1.00)	(0.200,0.529,1.00)	(0.250,0.530,1.000)	(0.250,0.699,1.000)	(1, 1, 1)

[CI:0.005, CR:0.095]

Results and Discussions

Table 5 shows a combination of the five judgment matrixes given by different experts together to gain pairwise comparison values for fuzzy AHP approaches. Based on the table on the teaching quality evaluation criteria, personal traits (0.476) carried the highest weight. The results indicated that the priority of personal traits is the maximum perceived by the experts in the university. Following the same procedure, the weights of the sub-criteria are calculated. Furthermore, the sub-criteria overall weights are multiplied by the corresponding main criteria weights to obtain a final weight of the sub-criteria. The results are described below in Table 6, 7, 8 and 9.

Table 5: Priorities with respect to teaching quality evaluation criteria

Rank	Name	Weight
1	Personal traits	0.476
2	Knowledge transfer	0.328
3	Knowledge evaluation	0.196

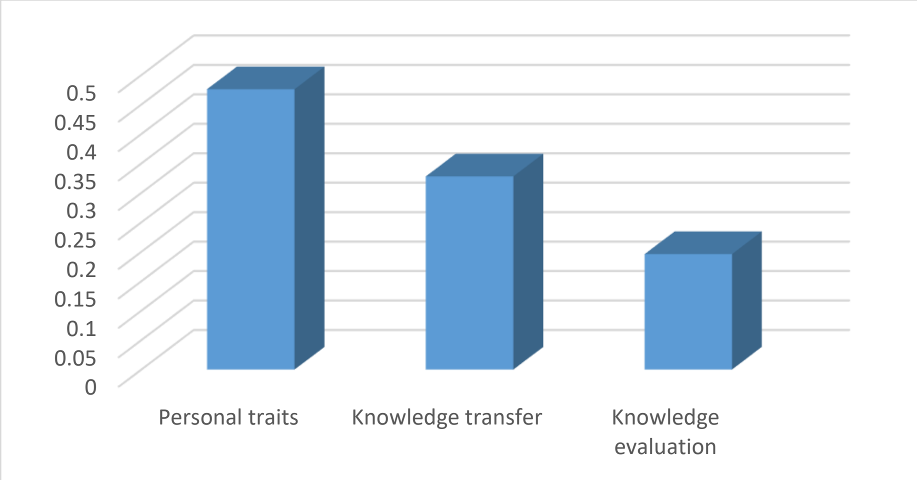

Fig. 3: Priorities with respect to teaching quality evaluation criteria

Table 6: Priorities with respect to personal traits

Rank	Name	Weight
1	S1	0.313
2	S2	0.258
3	S3	0.21
4	S4	0.152
5	S5	0.067
6	S6	0.001
7	S7	0

As shown in Table 6, speech culture (S1) is the main priority on the teaching criteria personal traits. The following priorities are S2, S3, S4, S5, S6 and S7, arranged in descending order according to the results of the weight.

Table 7: Priorities with respect to knowledge transfer

Rank	Name	Weight
1	S8	0.141
2	S9	0.124
3	S10	0.115
4	S11	0.111
5	S12	0.099
6	S13	0.09
7	S14	0.088
8	S15	0.071
9	S16	0.06
10	S17	0.055
11	S18	0.047

As shown in Table 7, according to the knowledge transfer, supply with adequate workloads (S8) is the main priority. Next priorities are assigned to S9, S10, S11, S12, S13, S14, S15, S16, S17 and S18 according to the obtained weights.

Table 8: Priorities with respect to knowledge evaluation

Rank	Name	Weight
1	S19	0.3
2	S20	0.222
3	S21	0.194
4	S22	0.168
5	S23	0.116

As shown in Table 8, according to the knowledge evaluation, S19 is the main priority. Next priorities are assigned to S20, S21, S22 and S23 according to the obtained weights. The following is the summary of teaching quality as perceived by the experts.

Table 9: Weights with respect to teaching quality evaluation criteria

Rank	Name	Attributes	Weight
1	S1	Speech culture	0.149
2	S2	Respect for student	0.123
3	S3	Appropriate appearance	0.10
4	S4	Responsiveness	0.072
14	S5	Punctuality	0.032
22	S6	Good manners	0.0005
23	S7	Ability to control and discipline students	0
6	S8	Supply with adequate workloads	0.046
8	S9	Oppose different theories	0.041
10	S10	Ask students about their goals	0.038
11	S11	Introduce the topic appropriately	0.036
13	S12	Ask students about their learning interests	0.0325
15	S13	Encourage students to focus on their interests and goals	0.03
16	S14	Provide with an appropriate practical example	0.03
17	S15	Explore learning issues fully	0.023
19	S16	Ensure the required supply of literature and handout materials	0.02
20	S17	Offer different viewpoints to the subject	0.018
21	S18	Inspire students for further reading	0.015
5	S19	Offer students to evaluate themselves	0.059
7	S20	Ask students how they intend to achieve the goals and tasks set	0.043
9	S21	Offer students to share their ideas and knowledge	0.038
12	S22	Explain to students why they were right or wrong	0.033
18	S23	Open new learning opportunities	0.023

As shown in Table 9, Speech Culture, S1 is perceived as the first priority according to an expert on the aspect of teaching quality evaluation criteria. It can be concluded from the key parameters and sub-criteria weights in the tables that there is a variance between the principal and sub-criteria priorities mentioned in the model. It is also noted that the priority of the key Personal traits parameters is the greatest. In the case of the sub-criteria, the priority is highest for ''speech culture'' under *Personal trait*, "supply with adequate workloads'' under *Knowledge transfer* and "offer students to evaluate themselves'' under *Knowledge evaluation*.

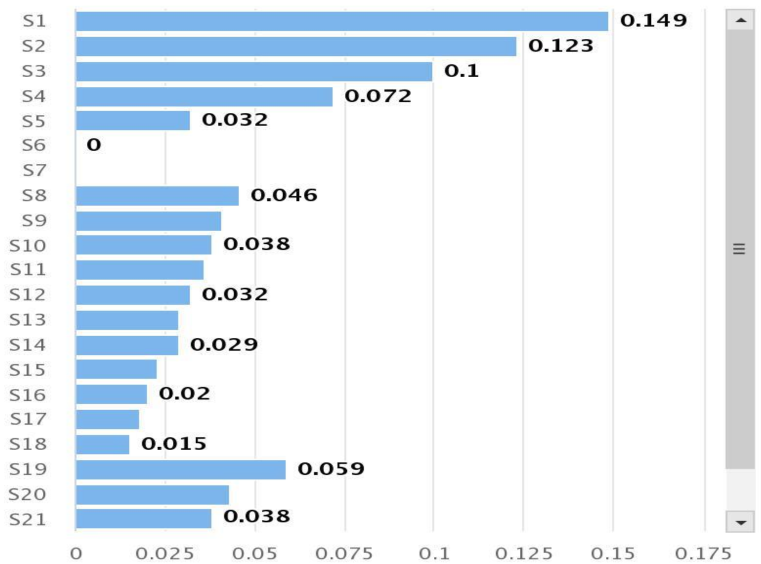

Fig. 5: Priorities with respect to teaching quality evaluation criteria

Conclusion

Overcoming the difficulties in deciding the level of importance for various variables of teaching quality in uncertain situations, the fuzzy logic can provide realistic measures. In this study, we applied fuzzy AHP in determining the level of each criteria and sub-criteria of teaching quality based on the expert opinions. Pairwise comparison is carried out and the ranking of each criteria is obtained through the calculations of priority weights. The teaching quality evaluation system which incorporates the uncertainties and qualitative knowledge of the problem domain is an important measure to improve teaching quality. By applying the model of the fuzzy expert method via different feedback scenarios, the qualitative variables are mapped into numerical outcomes and provide a basis for using the method ranking for further decision making. In the view of the existing problem in the evaluation of teaching quality, lecturers at the foundation centre under study must understand and consistently improve their personal traits. At the same time, to pay adequate attention to the knowledge evaluation of teaching quality. This study has given management of higher learning essential criteria to be included in the student evaluation of lecturer. It has the full potential to be continued, which integrate the subject expert's priorities with students' evaluation. The model of the fuzzy expert method is an essential feature of this topic that should be centred in the future. It should be applied to all forms of staff evaluation in universities as well as in other government and private organisations.

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