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Fuzzy Comprehensive Evaluation Method for Higher Education

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Abstract: The higher education system in India is changing at an unprecedented rate. Having an effective system for evaluating the quality is an essential key to realizing the goals of education. The adoption of the fuzzy formalism is a possible solution to the standardization in the domain of quality of education. In this paper, an analytical tool has been developed to find the important attributes which should be present in higher academic institutions for quality assurance. It uses fuzzy set principles to represent the imprecise concepts for subjective judgement and applies a Fuzzy Analytical Hierarchy Process (AHP) with extent analysis to determine the assessment criteria and their corresponding weights. A questionnaire was prepared for pair-wise comparison of the attributes and reviews were taken from the students, faculty and experts from industry. Triangular fuzzy numbers produced from the experts' view of the questionnaires are used for pair-wise comparison matrices.

Keywords: Fuzzy Logic, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, Extent Analysis, Pair-wise comparison.

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1. Introduction

High quality and relevant higher education is able to equip students with the knowledge, skills and core transferable competences within a high quality learning environment. A high quality, sustainable higher education sector is of great importance to robust and sustainable social, economic and political growth of a nation. Quality assurance allows people to have confidence in the quality of higher education. This is the reason every higher education institution aspires to have a rigorous system of internal quality assurance.

An education system (ES) or process consists of three different stages, namely, Input, The Process and Output with a feedback mechanism which makes it a closed loop system . Education system is a dynamic process which needs to continually improve, evolve and develop with the rapidly changing demands. The feedback coming from the output can be utilized to assess and improve the quality of education system. The main stakeholders of any education system are faculty, students, management and the infrastructure, which are in turn responsible for efficient functioning of an education system. Synergistic and efficient working of all these stakeholders results into a good or high quality higher education system which in turn leads to quality education.

1.1 Quality in Higher Education

Many definitions of quality in education exist, testifying to the complexity and multifaceted nature of the concept. The terms efficiency, effectiveness, equity and quality have often been used synonymously. Different approaches have been adopted by the researchers to define and evaluate quality in an educational institute. The identification of best practices to be implemented in an educational institute depends on many variables such as institutional goals, pedagogic requirements, global concerns, local contexts, nature of learners, competencies of staff, infrastructure facilities and governance requirements. It is observed that usually there is incongruence between how we teach and how students learn. All these add to the complexity of choice of best practices. What might be considered as best practice depends on our own limited knowledge, perspectives, contexts, interests and values. The attributes and values on which the practices are premised may be contested by others. In that case, many of the attributes on which the practices are premised will not hold. Secondly, attributes are contingent, context dependent and defy generic description. If these practices are to be useful at all, we need to identify the attributes that can be so restated as to be clearly seen to contribute to value addition to the institution or the

stakeholders. Only then can they become context-free and less subjective. This requires a predominantly fitness for purpose judgement and there cannot be an ideal typification of best attributes applicable to all contexts.
From the early 1990s onwards the emphasis was shifted to formal assessments of quality in technical education to spur the institutions to adopt formal systems of quality management. Singhand Sareen[2] described Deming's cycle and its 14 points which are used to ensure the quality of technical education process.Kaur et al. [3] studied and presented a comprehensive list of the quality issues in technical institutions where implementation of ISO 9001:2000 may provide the management a frame work to continually improve the existing resources and process by setting up quality objectives, measurements etc. to achieve higher standards of quality in education. TartagliaandTresso [4] developed a Web-based automatic evaluation system for students of engineering faculties.

Temponi [5] analyzed the main elements of continuous improvement (CI) in higher education and the concerns of academia's stakeholders in the implementation of such an approach. Thakkar et al. [28] used a quality function deployment (QFD) which prioritizes technical requirements and correlates them with various customers' students requirements for the present Indian context. Voss and Gruber[6] studied and gave an insight into the desired qualities of the lecturers. They indicated that the students want lecturers to be knowledgeable, enthusiastic, approachable, and friendly. Mahapatra and Khan [7]gave a measuring instrument known as EduQUAL for evaluation of quality in Technical Education System (TES).Neural network models along with QFD have been proposed to assess the degree of satisfaction of various stakeholders in ES. He gave certain factors that are important for assessing quality in technical education. Venkataram and Giridharan [1] designed a Technical Educational Quality Assurance and Assessment (TEQ-AA) System, which makes use of the information on the web and analyzes the standards of the institution. Mahapatra and Khan [8]designed a measuring instrument known as EduQUAL and an integrative approach using neural networks for evaluating service quality is proposed. The dimensionality of EduQUAL is validated by factor analysis followed by varimax rotation. Bahzad and Irani [9] developed a QA model for military institutions. The research seeks to assess, through a case study how newly established education institute assimilates quality assurance systems. Gheorgheet. al. [10] depicted the peculiarity of Quality Function Deployment method (QFD) applied to quality improvement in higher technical education. Wang and Liang [11] used SPC (control charts) technique for quality control or improvement of technical education.

1.2 The Analytical Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty[29,30]. The advantage of this method lies in its capability to handle multiple criteria and it can also handle both the quantitative and qualitative data effectively.AHP organizes the basic rationality by breaking down a problem into its smaller constituent parts. By decomposing the problem, the decision-maker can focus on a limited number of items at the same time. The AHP is carried out in two phases: the design of the hierarchy and the evaluation of the components in the hierarchy. AHP is a multi-criteria decision making process that is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. It is based on the assumption that when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics. It is a technique for decision making where there are a limited number of choices, but where each has a number of different attributes, some or all of which may be difficult to formalize. It is especially applicable when a team is making decisions. It involves building a hierarchy (ranking) of decision elements and then making comparisons between each possible pair in each cluster (as a matrix). This gives a weighting for each element within a cluster (or level of the hierarchy) and a consistency ratio (useful for checking the consistency of the data).It involves the use of principles of decomposition, pair-wise comparisons, priority vector generation and synthesis. The purpose of AHP is to capture the expert's knowledge and analyze it.

The crux of AHP is the determination of the relative weights to rank the decision alternatives. Assuming that there are n criteria at a given hierarchy, the procedure establishes an $n \times n$ pairwise comparison matrix, A, that reflects the decision maker's judgment of the relative importance of the different criteria. The pair-wise comparison is made such that the criterion in row i ($i = 1,2,3,....,n$) is ranked relative to each of the criteria represented by the n columns. Letting aij define the element (i,j) of A, AHP uses a discrete scale from 1 to 9 in which aij = 1 signifies that i and j are equally important, aij = 5 indicates that i is strongly more important than j and aij = 9 indicates that i is extremely more important than j. Other intermediate values between 1 and 9 are interpreted correspondingly. Preference weight values for different level of significance for AHP model are depicted in Table 1. For consistency, aij = k automatically implies that aji = 1/k. Also all the diagonal elements aii of A must equal 1 because they rank a criterion against itself. The relative weights of criterion can be determined from A by dividing the elements of each column by the sum of the elements of the same column. The resulting matrix is called normalized matrix, N. The numerical results of attributes are presented to the decision maker to assign relative importance according to a predefined scale.

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Table 1: Preference weight values for different level of significance for AHP model

Significance/ Weights	Definition	Explanation
1	Equal importance	Two attributes contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one attribute over another
5	Essential or strong importance	Experience and judgment strongly or essentially favor one attribute over another
7	Demonstrated or confirmed importance	An attribute is strongly favored over another and its dominance demonstrated in practice
9	Extreme or Absolute importance	The evidence favoring one attribute over another is of the highest degree possible of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	Used to represent compromise between the preferences listed above

1.3 Fuzzy Analytical Hierarchy Process

The conventional AHP method does not reflect the heuristic reasoning ability of human beings. The AHP method is mainly used in nearly crisp decision applications because it does not take into account the uncertainty associated with the mapping of one's judgment to a number. Since a decision-maker's requirements on evaluating alternatives always contain ambiguity and multiplicity of meaning, ranking of the AHP method is rather imprecise. In order to model this kind of uncertainty in human preferences, fuzzy sets could be incorporated with the pairwise comparison as an extension of AHP.

Fuzzy Analytical Hierarchy Process (FAHP) is a synthetic extension of classical AHP method when the subjective judgment, selection and preference of decision-makers have great influence on the AHP results. It overcomes the compensatory approach and the inability of the AHP in handling linguistic variables. The earliest work in fuzzy AHP started from 1983.Laarhoven and Pedrycz [15] compared fuzzy ratios described by triangular membership functions. Chang introduced a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, with the use of the extent analysis method for the synthetic extent values of the pairwise comparisons. Stam et al. [16] explored the recently developed artificial intelligence techniques that can be used to determine or approximate the preference ratings in AHP. They concluded that the feed-forward neural network formulation is a powerful tool for analyzing discrete alternative multi-criteria decision problems with imprecise or fuzzy ratio-scale preference judgments. Cheng [17] proposed an algorithm for evaluating naval tactical missile systems by using fuzzy AHP, based on grade value of membership function. Later in the same year, Weck et al. [19] gave a method for evaluating different production cycle alternatives which added mathematics of fuzzy logic to the classical AHP.

Kahraman et al.[27] employed a fuzzy objective and subjective method and obtained the weights from AHP and then made a fuzzy weighted evaluation. Deng [20] presented a fuzzy approach for tackling qualitative multi-criteria analysis problems in a simple and easierway. Lee et al. [21] review the basic ideas behind the AHP. Based on the ideas, they introduced the concept of comparison interval and proposed a methodology based on stochastic optimization to achieve global consistency and to accommodate the fuzzy nature of the comparison process. Cheng et al. [22] proposed a new method for evaluating weapon systems by AHP which was based on linguistic variable weight. Zhu et al. [23] carried out a discussion on extent analysis method and applications of fuzzy AHP. Later, Chan et al. [24] developed a technology selection algorithm to quantify both tangible and intangible benefits that are present in fuzzy environment. They described an application of the fuzzy set theory to hierarchical structural analysis and economic evaluations. Leung and Cao [25]proposed a fuzzy consistency definition by considering tolerance deviation. Then the fuzzy ratios of relative importance with certain tolerance deviation were formulated as constraints on the membership values of the local priorities. Later in the same year, Chan et al. [26]presented an integrated approach for automatic design of FMS, which used simulation and MCDM techniques. Kahraman et al. employed fuzzy AHP technique for comparison of catering service companies. He carried out the process on certain main and sub attributes which were proposed by experts that are required in a catering firm. He then proposed the best firm out of the three firms presented and also concluded that fuzzy AHP can be effectively applied in the given field.

1.4 Extent Analysis Method on Fuzzy AHP

Extent analysis method is a novel approach for handling fuzzy AHP. It is used to obtain a crisp priority vector from a triangular fuzzy comparison matrix.

Let X = {x1, x2… xn} be an object set, and U = {u1, u2… um} be a goal set. According to the method of Chang's extent analysis [14], each object is taken and extent analysis for each goal, gi, is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{gi}^{1}, M_{gi}^{2}, \ldots\ldots, M_{gi}^{m}, i = 1,2,\ldots., n$$

Where, all the M_{gi}^{j}(j =1, 2…..m) are Triangular Fuzzy Numbers.

The steps of Chang's extent analysis can be summarized as follows,

Step 1: The value of fuzzy synthetic extent with respect to the i^{th}object is defined as,

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that,

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$$

To obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$, perform the fuzzy addition operation of M^{j}_{gi} (j =1, 2…..m) values such that ;

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_j, \sum_{i=1}^{n} m_j, \sum_{i=1}^{n} u_j \right)$$

The inverse of the vector in the above equation can be written as,

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

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_l, u_1)$is defined as :

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

To compare M_1 and M_2,both the values of $V(M_2 \geq M_1)$and$V(M_1 \geq M_2)$ are required.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i=1, 2,….., k)can be defined as $V(M \geq M_1, M_2, \ldots, M_k) = V[(M \geq M_1)and(M \geq M_2)$ and … and $(M \geq M_k)] = \min V(M \geq M_i)$, i= 1,2, 3,…….k.

Assuming that$d'(A_i) = \min V(S_i \geq S_k)$for, k=1,2,…..,n and $k \neq i$. Then the weightvector is given by,

$W' = \left(d'(A_1), d'(A_2), \ldots\ldots\ldots, d'(A_n) \right)^T$,where, Ai(i=1, 2, 3….. n) are n elements.

Step 4: Via normalization, the normalized weight vectors are given as [14],

$W = \left(d(A_1), d(A_2), \ldots\ldots\ldots, d(A_n) \right)^T$ where, "W" is a non- fuzzy number.

2. Application of Fuzzy AHP to evaluate attributes for Quality Assurance in Higher Education

Considerable consensus exists around the basic dimensions of quality which includes students who are ready to participate and learn, content that is reflected in relevant curricula and materials for the acquisition of skills required, well trained faculty, infrastructure facilities, etc. In this paper a comprehensive evaluation method based on Fuzzy AHP is proposed which can be used as an effective tool to assure quality in Higher Education System. This multi criterion decision making (MCDM) tool can help in monitoring, controlling and improving the quality of higher education at various levels. Fuzzy AHP technique is used for finding out the weightage of the main and sub criterion attributes to assure quality in higher education system. The proposed work tests the adequacy of Fuzzy AHP for modeling the attributes of quality in education as well as deciding their relative ranking and significance in a given case study.

The decision maker specifies the preferences in the form of natural language expressions about the importance of each performance attribute (faculty, student, management inputs and infrastructure) and the system combines these preferences using fuzzy-AHP, with existing data (from industrial surveys and statistical analysis) to reemphasize attribute priorities. Table 2 represents preference weight values for different level of importance for Fuzzy AHP model. In the fuzzy-AHP methodology, the pairwise comparisons in the judgment matrices are fuzzy numbers that are modified by the designer. Using fuzzy arithmetic and a-cuts, the procedure calculates a sequence of weight vectors that will be used to combine the scores on each attribute. The procedure calculates a corresponding set of scores and determines one composite score that is the average of these fuzzy scores.

2.1 Determination of Criteria

Based on the extensive literature review given in the previous section and views of experts participating in the implementation of this model, four important attributes of an education system in order to assure quality are shortlisted. The attributes are: Faculty Quality (FQ), Students Quality (SQ), Management Inputs (MI) and Infrastructure (IN). In addition to these main attributes, certain sub attributes belonging to each main attribute category were also shortlisted as follows:-

Faculty Quality: Subattributes are Faculty expertise, Adequacy of subject teacher, Effective classroom management, Teaching quality and productivity, Amount of teaching and industrial experience (T&I Ex), Good communication skills (GCS), Qualifications of Faculty (Qua), Expertise in Subject and Well-Organised Lectures (ES & WOL).

Students Quality: Sub attributes are Background and merits of the students (B & MES), Fraction engaging in undergraduate research, Fraction completing graduation as per the university norms, Time taken to complete the degree (TLD), Attitude towards learning (ATL)

Management Inputs: The lack of adequate inputs by the management and non provision of qualified, well paid and professional faculty adversely affects the quality of technical education. Some of the major sub attributes to be considered by the management are as follows; Training for Faculty Development (TFD), Timely Assessment of Faculty and Students (T A F&S), Library Standards (LS), Adaptability to modern techniques. Curriculum Design (CD), Opportunities for campus training and placement (T&P), Transparency of procedure and norms

Infrastructure in an Institution: Good infrastructure facilities are essential requirement for any higher education system. Sub attributes under this category are Well-equipped laboratories with modern facilities (WO L&C), Cleanliness, orderliness, systematic and methodical approach (COSM) of the institute, College building and premises (CBP), Hostel and Mess facility (HMF), etc.

Table 2: Preference weight values for different level of importance for Fuzzy AHP model.

Linguistic scale for importance	Fuzzy Numbers	Membership function	Domain	Triangular fuzzy scale (l, m, u)
Just equal				(1, 1, 1)
Equally important	$\tilde{1}$	$\mu M(x) = (3-x) / (3-1)$	$1 \leq x \leq 3$	(1, 1, 3)
Weakly important	$\tilde{3}$	$\mu M(x) = (x-1) / (3-1)$	$1 \leq x \leq 3$	(1, 3, 5)

		μM(x) = (5-x) / (5-3)	$3 \le x \le 5$	
Essential or Strongly important	$\tilde{5}$	μM(x) = (x-3) / (5-3)	$3 \le x \le 5$	(3, 5, 7)
		μM(x) = (7-x) / (7-5)	$5 \le x \le 7$	
Very strongly important	$\tilde{7}$	μM(x) = (x-5) / (7-5)	$5 \le x \le 7$	(5, 7, 9)
		μM(x) = (9-x) / (9-7)	$7 \le x \le 9$	
Extremely Preferred	$\tilde{9}$	μM(x) = (x-7) / (9-7)	$7 \le x \le 9$	(7, 9, 9)
If factor I has one of the above numbers assigned to it when compared to factor j, then j has the reciprocal value when compare to i				

2.2 Data Collection

For multi-criteria inventory classification, a questionnaire was designed to elicit judgments about the relative importance of each of the selected attributes (main & sub) for Pairwise Comparison of Criteria. The questionnaire was completed by a number of students, faculty, recruiters and people working in the industry.

2.3 Data Analysis and Calculations

Tables 3-7 show the pairwise comparison matrices for the main and sub attributes. These were constructed with the responses obtained from the comparison questionnaire. The values of priority vectors were calculated for all the main and sub attributes.

Table 3 Main Attributes Pairwise Comparison Matrix

Main Attributes	FQ	SQ	MI	IF
FQ	(1,1,1)	(7/2,4,9/2)	(3/2,2,5/2)	(2/3,1,3/2)
SQ	(2/9,1/4,2/7)	(1,1,1)	(2/3,1/2,2/3)	(5/2,3,7/2)
MI	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(5/2,3,7/2)
IF	(2/3,1,3/2)	(2/7,1/3,2/5)	(2/7,1/3,2/5)	(1,1,1)

From table 3, following values are obtained

$$S_{FQ} = (6.67, 8.00, 9.50) \otimes \left[\frac{1}{25.93}, \frac{1}{21.93}, \frac{1}{18.44}\right] = (0.26, 0.36, 0.52),$$

$$S_{SQ} = (4.12, 4.75, 5.46) \otimes \left[\frac{1}{25.93}, \frac{1}{21.93}, \frac{1}{18.44}\right] = (0.16, 0.22, 0.30),$$

$$S_{MI} = (5.40, 6.50, 7.70) \otimes \left[\frac{1}{25.93}, \frac{1}{21.93}, \frac{1}{18.44}\right] = (0.21, 0.30, 0.42),$$

$$S_{IN} = (2.25, 2.48, 3.30) \otimes \left[\frac{1}{25.93}, \frac{1}{21.93}, \frac{1}{18.44}\right] = (0.09, 0.12, 0.18).$$

Hence the values of vectors are obtained as follows;

V ($S_{FQ} \geq S_{SQ}$) = 1, V ($S_{FQ} \geq S_{MI}$) = 1, V ($S_{FQ} \geq S_{IN}$) = 1;
V ($S_{SQ} \geq S_{FQ}$) = 0.22, V ($S_{SQ} \geq S_{MI}$) = 0.09, V ($S_{SQ} \geq S_{IN}$) = 1;
V ($S_{MI} \geq S_{FQ}$) = 0.73, V ($S_{MI} \geq S_{SQ}$) = 1, V ($S_{MI} \geq S_{IN}$) = 1;
V ($S_{IN} \geq S_{FQ}$) = 0.15, V ($S_{IN} \geq S_{SQ}$) = 0.25, V ($S_{IN} \geq S_{MI}$) = 0.18.

Hence the weight vector from table 3 can be calculated as $W_{MA} = (0.48, 0.11, 0.35, 0.06)^T$
Similarly the sub attributes for each of the main attributes are compared (table 4-7) and the corresponding values of vectors are calculated.

Table 4 Sub Attributes of Faculty Quality Pairwise Comparison Matrix

Faculty Quality Sub- Attributes	GCS	Qua	T&I Ex	E S&WOL
GCS	(1,1,1)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)
Qua	(1,1,1)	(1,1,1)	(7/2,4,9/2)	(3/2,2,5/2)
T&I Ex	(2/7,1/3,2/5)	(2/9,1/4,2/7)	(1,1,1)	(2/3,3,3/2)
E S& WOL	(2/5,1/2,2/3)	(2/3,1/2,2/5)	(2/3,1,3/2)	(1,1,1)

From table 4, following values are obtained,

S_{GCS}= (0.25, 0.34, 0.45),
S_{Qua}= (0.30, 0.39, 0.50),
$S_{T\&I\ Ex}$ = (0.10, 0.13, 0.18),
$S_{E\&S\ WOL}$ = (0.12, 0.15, 0.20);
V ($S_{GCS} \geq S_{Qua}$) = 0.75, V ($S_{GCS} \geq S_{T\&I\ Ex}$) = 1, V ($S_{GCS} \geq S_{E\&S\ WOL}$) = 1;
V ($S_{Qua} \geq S_{GCS}$) = 1, V ($S_{Qua} \geq S_{T\&I\ Ex}$) = 1,V ($S_{Qua} \geq S_{E\&S\ WOL}$) = 1;
V ($S_{T\&I\ Ex} \geq S_{GCS}$) = 0.43, V ($S_{T\&I\ Ex} \geq S_{Qua}$) = 0.28, V ($S_{T\&I\ Ex} \geq S_{E\&S\ WOL}$) = 0.60;
V ($S_{E\&S\ WOL} \geq S_{GCS}$) = 0.22, V ($S_{E\&S\ WOL} \geq S_{Qua}$) = 0.15,V ($S_{E\&S\ WOL} \geq S_{T\&I\ Ex}$) = 1.

Hence the weight vector from table 4 is calculated as $W_{FQSA} = (0.35, 0.46, 0.13, 0.06)^T$

Table 5 Sub Attributes of Students Quality Pairwise Comparison Matrix

Students Quality Sub- Attributes	B & MES	ATL	TCD
B & MES	(1,1,1)	(3/2,2,5/2)	(2/3,1,3/2)
ATL	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)
TCD	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)

From table 5, following values are obtained,
$S_{B\&M\ ES}$= (0.26, 0.40, 0.61);
S_{ATL}= (0.24, 0.35, 0.51);
S_{TCD}= (0.17, 0.25, 0.39);
V ($S_{B\&M\ ES} \geq S_{ATL}$) = 1, V ($S_{B\&M\ ES} \geq S_{TCD}$) = 1;
V ($S_{ATL} \geq S_{B\&M\ ES}$) = 0.84, V ($S_{ATL} \geq S_{TCD}$) = 1;
V ($S_{TCD} \geq S_{B\&M\ ES}$) = 0.47, V ($S_{TCD} \geq S_{ATL}$) = 0.61.
Hence the weight vector from table 5 can be calculated as $W_{SQSA} = (0.43, 0.37, 0.20)^T$

Table 6: Sub Attributes of Management Inputs Pairwise Comparison Matrix

Management Inputs Sub- Factors	TFD	CD	LS	TA F&S	T&P
TFD	(1,1,1)	(2/9,1/4,2/7)	(3/2,2,5/2)	(1,1,1)	(2/3,1,3/2)
CD	(7/2,4,9/2)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)	(1,1,1)
LS	(2/5,1/2,2/3)	(2/7,1/3,2/5)	(1,1,1)	(2/5,1/2,2/3)	(2/7,1/3,2/5)
TA F&S	(1,1,1)	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(1,1,1)
T&P	(2/3,1,3/2)	(1,1,1)	(5/2,3,7/2)	(1,1,1)	(1,1,1)

From table 6, the weight vector is calculated as $W_{MISA} = (0.11,0.47,0.07,0.18,0.17)^T$

Table 7 Sub Attributes of Infrastructure Pairwise Comparison Matrix

Infrastructure Sub- Factors	CBP	WE LC	COSM	HMF
CBP	(1,1,1)	(2/9,1/4,2/7)	(3/2,2,5/2)	(3/2,2,5/2)
WE LC	(7/2,4,9/2)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)
COSM	(2/5,1/2,2/3)	(2/7,1/3,2/5)	(1,1,1)	(1,1,1)
HMF	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(1,1,1)	(1,1,1)

From table 7, the weight vector is calculated as $W_{INSA} = (0.17,0.68,0.09,0.06)^T$

Table 8: Summary of Global Priority Weights of Main Attributes and Sub Attributes for Assessing Quality in Higher Education

Ranking of Main and Sub Attributes	Global Priority Weights
Faculty quality (FQ)	**0.4800**
Good Communication Skills (GCS)	0.1632
Qualification of Faculty (Qua)	0.2208
Teaching & Industrial Experience (T&I Ex)	0.0624
Expertise in Subject and Well Organised Lectures (ES&WOL)	0.0336
Students Quality(SQ)	**0.1100**
Background & Merit of Students (B&MES)	0.0473
Attitude Towards Learning (ATL)	0.0407
Time Taken to Complete Degree(TCD)	0.0220
Management Inputs (MI)	**0.3500**

Training for Faculty Development (TFD)	0.0385
Curriculum Design (CD)	0.1645
Library Standards(LS)	0.0245
Timely Assessment of Faculty & Students (TA F&S)	0.0630
Training & Placement(T&P)	0.0595
Infrastructure (IN)	**0.0600**
College Building & Premises (CB&P)	0.0102
Well Equiped Labs and Classrooms (WEL&C)	0.0408
Cleanliness, Orderliness, Systematic and Methodical Approach (COSM)	0.0054
Hostel and Mess Facility(HMF)	0.0036

Conclusion

A novel comprehensive evaluation tool based on Fuzzy AHP is proposed as a systematic integrated approach for modeling various attributes of a quality higher education system. In recent years, because of the characteristics of information and decision makers, probable deviation should be integrated to the decision making processes, and Fuzzy AHP method is a natural result of this necessity. Since education is a service sector, policy framing and quality control is a complex decision making process. It has to take into account social, economic, technical and political factors that need to be evaluated by linguistic variables.

In the study presented, contributing attributes for a good quality higher education system were determined using literature review and a questionnaire constructed to consider reviews from students, faculty and some experts from industry. Fuzzy AHP technique was used to synthesize the opinions of the decision makers to identify the weight of each attribute. After identifying weights of each attribute fuzzy AHP comparison matrices were calculated and using extent analysis method global priority weights for each attribute were calculated which are tabulated in Table 8. It shows that Faculty Quality has higher priority (0.480) over other attributes. Amongst the sub attributes, the Qualification of Faculty (Qua) has highest weight vector (0.2208) followed by Good Communication Skills (0.1632).The Fuzzy AHP based evaluation tool is also very flexible in the sense that the decision makers can incorporate some other attributes or remove any attributes for different institutions. Depending upon the specific case, different classification analysis can also be done. It also gives the user the ability to use application-specific linguistic variable set. The Fuzzy AHP approach proved to be a convenient method in tackling practical multi-criteria decision making problems. It demonstrated the advantage of being able to capture the vagueness of human thinking and aid in decision making in a structured manner.

References

[1]. Venkataram P & Giridharan A, "Quality Assurance and Assessment in Technical Education System: A Web Based Approach", ICEE 2007.
[2]. Singh C & Sareen K, "Application of Deming's Philospphy to Improve the Quality of Technical Education", emerald 2001.
[3]. Kaur M, Singh C, & Sareen K.K, " Improving Quality of Technical Education using ISO 9000:2000", emerald 2002.
[4]. Tartaglia A & Tresso E, "An Automatic Evaluation System for Technical Education at the University Level", IEEE VOL.45, No.3,2002.
[5]. Temponi C, "Continuous improvement framework: implications for academia", Emerald Group, Quality Assurance in Education Vol. 13 No. 1, 2005.
[6]. Voss R & Gruber T, "The desired teaching qualities of lecturers in higher education: a means end analysis", Emerald Group Quality Assurance in Education Vol. 14 No. 3, 2006.
[7]. Mahapatra S. S & Khan M. S, "A neural network approach for assessing quality in technical education: an empirical study", International Journal of Productivity and Quality Management, Vol.2, No.3, 2007.
[8]. Mahapatra S. S & Khan M. S, "A framework for analyzing quality in education settings", European Journal of Engineering Education Vol. 32, No. 2, 205–217, May 2007.
[9]. Bahzad Y and Irani Z, "Developing a Quality Assurance Model for Small Military Institutions", European and Mediterranean Conference on Information Systems 2008 (EMCIS2008) May 25-26 2008.
[10]. Gheorghe C.M, Constantinescu D & Covrig M, "The Determination of Factors Underlying Decision Making Process on Quality Improvement in Technical Education", IEEE 2008.
[11]. Wang Z and Liang R, "Discuss on Applying SPC to Quality Management in University Education", The 9th International Conference for Young Computer Scientists, IEEE, 2008.

[12]. Inamullah H.M, Naseeruddin M & Hussain I, "The Development of Technical Education in Pakistan", International Business & Economics Research Journal, Volume 8, Number 1, January 2009.
[13]. Zadeh, L., "Fuzzy sets", Information Control 8, 338–353,1965.
[14]. Chang, D.-Y., "Applications of the extent analysis method on fuzzy AHP", European Journal of Operational Research,95, 649–655,1996.
[15]. Laarhoven V, P.J.M., Pedrycz, W., "A fuzzy extension of Saaty's priority theory", Fuzzy Sets and Systems, 11, 229–241, 1983.
[16]. Stam, A., Minghe, S. & Haines, M., "Artificial neural network representations for hierarchical preference structures", Computers and Operations Research 23 (12), 1191–1201,1996.
[17]. Cheng, C.-H., "Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function", European Journal of Operational Research96 (2), 343–350,1997.
[18]. Kahraman C, Cebeci U & Ruan D, "Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey", Int. J. Production Economics 87 (2004) 171–184, 2003.
[19]. Weck, M., Klocke, F., Schell, H., R.uenauver, E., "Evaluating alternative production cycles using the extended fuzzy AHP method", European Journal of Operational Research 100 (2), 351–366, 1997.
[20]. Deng, H., "Multicriteria analysis with fuzzy pairwise comparison", International Journal of Approximate Reasoning, 21 (3), 215–231, 1999.
[21]. Lee, M., Pham, H. & Zhang, X., "A methodology for priority setting with application to software development process", European Journal of Operation al Research, 118, 375–389,1999.
[22]. Cheng, C.-H., Yang, K.-L., Hwang, C.-L., "Evaluating attack helicopters by AHP based on linguistic variable weight", European Journal of Operation al Research 116 (2),423–435,1999.
[23]. Zhu, K.-J., Jing, Y., Chang, D.-Y., "A discussion of extent analysis method and applications of fuzzy AHP", European Journal of Operational Research 116, 450–456, 1999.
[24]. Chan, F.T.S., Chan, M.H., Tang, N.K.H., "Evaluation methodologies for technology selection", Journal of Materials Processing Technology 107, 330–337, 2000a.
[25]. Leung, L.C., Cao, D., "On consistency and ranking of alternatives in fuzzy AHP", European Journal of Operational Research 124, 102–113, 2000.
[26]. Chan, F.T.S., Jiang, B., Tang, N.K.H., "The development of intelligent decision support tools to aid the design of flexible manufacturing systems", International Journal of Production Economics, 65 (1), 73–84,2000b.
[27]. Kahraman, C., Ulukan, Z. &Tolga, E., "A fuzzy weighted evaluation method using objective and subjective measures", Proceedings of the International ICSC Symposium on Engineering of Intelligent Systems (EIS'98), Vol. 1, University Laguna Tenerife, Spain, pp. 57–63, 1998.
[28]. Thakkar J & Shastree A, "Total quality management (TQM) in self-financed technical institutions", Emerald Group. Quality Assurance in Education Vol. 14 No. 1, 2006.
[29]. T.L. Saaty, "The analytic hierarchy process", New York, NY: McGraw-Hill, 1980.
[30]. T.L. Saaty, "Fundamentals of Decision Making and Priority Theory", 2nd ed. Pittsburgh, PA: RWS Publications, 2000.