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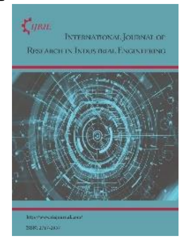

Improvement of the Student-Teacher Learning Interface with Selecting and Designing a Teaching Method

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A B S T R A C T

This Research work explores the effective teaching method using a single case study design and produces a plenty of information about students requirements, teachers recommendations and some teaching methods and learning styles .The resulting analysis provides a complete teaching method that may develop teacher student learning interface as well as may satisfy both student's requirements and the recommendations of teacher. The analysis also specifies the component essential to develop the relationship between teacher and students as well as the learning environment. In this analysis at first some literature review is done to know the aspects of teaching and learning methods and also different types of teaching and learning methods. From this it is easy to understand what should be the focus of learning and the strategy that can help students to empower themselves with their own thinking power. Then the survey is done among 250 students of Rajshahi University of Engineering and Technology to know the students requirements and teachers' recommendation is also brought from the discussion with the teachers of this institute. After that according to the students requirements and teachers recommendation the candidates of teaching method is selected. And finally the Fuzzy Topsis Set Theory is applied to find out the effective teaching method which satisfies the student requirements. The characteristics and advantages are also mentioned which are able to alleviate the gaps that exist in the previous teaching methods.

Keywords: Teaching method, Learning style, Quality function deployment, Fuzzy Topsis.

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1. Introduction

Current trends in technology and our increasingly complex society requires engineers having a greater variety of capabilities, skills, and a wider understanding of engineering as a discipline. The limitations of traditional teaching and learning styles due to the lack of employing of whole brain cause engineering students encounter many problems in the learning process. According to [1, 2], the brain can be visualized as a four quadrants metaphorical model that are labeled A (mathematical, analytical, critical thinking), B (sequential, controlled, routine thinking), C (interpersonal, empathetic, symbolic thinking), D (imaginative, visual, conceptual thinking). Each quadrant is characterized by distinct ways of thinking, knowing, and processing information. Engineering education on the average by skewing toward a strong preference in quadrant C thinking has caused many engineering students and even professors be predominantly left-brain thinkers. This causes when engineering students are graduated they will encounter many problems in their work place that require different thinking abilities. So the researches confirm that quadrants C and D activities must be part of the engineering curriculum [1, 2]. Critical Problem Solving (CPS) that employs whole brain of students can play an important role to provide new generation of engineers for human capital. The roots of CPS are found in Osborn's works and it followed by many researchers like Parnes, IsaksenandTreffinger, Isaksen etc. The authors [5, 6] stated that the CPS as five distinct steps: (i) Problem Definition, (ii) Idea Generation, (iii) Creative Idea Evaluation, (iv) Idea Judgment, (v) Solution Implementation and show the relations between these stages and the four-quadrant thinking of brain in Herrmann Model. They believe that the process of CPS involves all analytical, creative, and critical thinking and it can be used to strengthen the quality of teamwork, thinking and communication skills of students in whole brain during of its stages.

Roselainy and collogue had developed and implemented their model of active learning in the teaching of Engineering Mathematics at UTM [3]. They considered classroom tasks; classroom activities; communication; assessment and self-direct learning in the implementation of active learning in engineering mathematics classroom. In other words, they had provided and promoted a learning environment where the mathematical powers are used specifically and explicitly, towards supporting students to become aware of the mathematics structures being learned; to recognize and use their mathematical thinking powers, and modify their mathematical learning behavior. Their model of active learning environment involves components that are approximately from whole brain such as communication and discussion. Awla [3] had defined and classified the concept of learning style and suggested a balanced teaching approach to cope with various learning styles.

Technically, an individual’s learning style refers to a particular way in which the student absorbs, manipulates and retains information. It is important for teachers to understand the differences in their students’ learning styles, so that they can implement best practice strategies into their daily activities, curriculum and assessment. There are different types of learning styles like- visual learning where people prefer to use pictures, diagrams, colors and mind maps; physical learners use their body to assist in their learning. Drawing diagrams, using physical objects, or role playing are the strategies of the physical learner; aural learners prefer learning using sound, rhythms, music, recordings and so on; verbal learners prefer using words, both in speech and in writing to assist in their learning; logical learners use logic, reasoning, and “systems” to explain or understand concepts. They aim to understand the reasons behind the learning, and have a good ability to understand the bigger picture; social learners enjoy learning in groups or with other people, and aim to work with others as much as possible; solitary learners prefer to learn alone and through self-study [4].

We can now consider a number of specific methods which can satisfy the requirements of different learners. It is however, important to note that the choice of any form of methods should not be arbitrary, but needs to be governed by the criteria of both teachers and students. At the same time each method is not fool-proof, but has its own advantages and disadvantages. That is why we would recommend the use of combined methods rather than one method.

There are different types of teaching methods like-lecture method (an oral presentation of information by the instructor where the instructor tells, explains, describes or relates whatever information the trainees are required to learn through listening and understanding. It is therefore teacher-centered. The instructor is very active, doing all the talking. Trainees on the other hand are very inactive, doing all the listening); discussion method (A two-way communication between participants where the instructor spends some time listening while the trainees spend sometimes talking); demonstration method (A method of instruction where the instructor by actually performing an operation or doing a job shows the students what to do, how to do it, and through explanations brings out why, where, and when it is done-to teach manipulative operations and troubleshooting); programmed instruction method (A method of self-instruction to provide remedial instruction and make-up instruction for late arrivals and absentees; to maintain previously learned skills which are not performed frequently enough; to provide retraining on equipment and procedures which have become obsolete and upgrade production, to accelerate capable students and provide enough common background among students); study assignment method (A method in which the instructor/teacher assigns reading to books, periodicals, project or research papers or exercises for the practice to orient students to a topic prior to classroom or laboratory work).

From the literature review we found several types of learning methods for the students and teaching methods for the teachers that can help students to empower themselves with their own thinking power and help them in construction of new knowledge and soft skills, particularly communication, team work and self-directed learning.

2. Methodology

In this research work a proper teaching method is designed to find out the students requirements which is added to the designing method. To find out their need a survey among 250 students of Rajshahi University of engineering and technology was done. The survey question of these case study is added to the appendix and the survey results are used to accomplish the quality function deployment to categorize the student's requirements and convert them into engineering specification (***Figure. 1***). From that it is easy to find out the top priority requirements and their effective specification. Fuzzy set of theory is also applied to analyze the sensitivity of the whole process.

3. Case Description

After analyzing the results of the survey from students we have found some of their requirements which are stated below:

- Learning through listening, speaking and group discussion (auditory learners).
- Learning through pictures, diagrams and videos (visual learners).
- Learning using physical objects (kinesthetic learners).
- Practical applications of subjective knowledge (industrial collaboration).
- Combination of self-study and group study.
- Wants teacher to teach in a strategic way to reduce complexity (highly instructive teacher).
- Delivery of lecture.
- One lesson in one lecture.
- Acoustical & ergonomically improvement.

3.1. Teachers Recommendations

- Students should be attentive and regular to their class and study.
- Students should participate in classroom discussion.
- Have to prepare their lesson what was done in previous lecture.
- Student should response when teacher ask to the class.
- Teacher should give practical example & its implementation during lecture.
- Student-teacher relationship should be better.

4. Fuzzy Set Theory

4.1. Definition

A fuzzy set a in a universe of discourse X is characterized by a membership function $\mu a(x)$ that maps each element x in X to a real number in the interval [0, 1]. The function value $\mu a(x)$ is termed the grade of membership of x .The nearer the value of $\mu a(x)$ to unity, the higher the grade of membership of x in a.

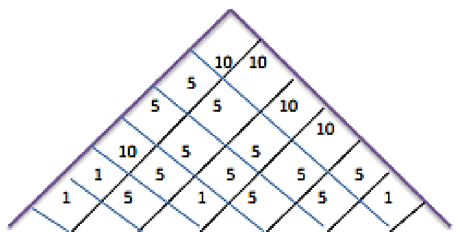
A triangular fuzzy number is represented as a triplet $a = (a_1, a_2, a_3)$. The membership function $\mu_a(x)$ of triangular fuzzy number a is given by $\mu_a(x)$ is equal to

$$\begin{cases} 0, x \leq a_1, \\ (x - a_1/a_2 - a_1), a_1 \leq x \leq a_2, \end{cases}$$

$$(a_3 - x / a_3 - a_2),\ a_2 \le x \le a_3,$$

$$0,\ x > a_3.$$

Where a_1, a_2, a_3 are real numbers and $a_1 < a_2 < a_3$. The value of x at a_2 gives the maximal grade of $\mu_a(x)$, i.e., $\mu_a(x) = 1$; It is the most probable value of the evaluation data. The value of x at a_1 gives the minimal grade of $\mu_a(x)$, i.e., $\mu_a(x) = 0$; It is the least probable value of the evaluation data. Constants a_1 and a_3 are the lower and upper bounds of the available area for the evaluation data. These constants reflect the fuzziness of the evaluation data .The narrower the interval [a_1, a_3], the lower the fuzziness of the evaluation data.



Engineering specifications → / Student requirements ↓	Ranking of Student (10)	% Importance	Verbal	Visual	Physical	Aural	Logical	Social	Solitary			
Auditory learning	10	12.5	10	1	1	10	5	5	5	M	P	P
Visual learning	10	12.5	1	10	5	1	10	5	5	P	M	P
Kinaesthetic learning	5	6.25	1	5	10	1	10	5	5	P	P	M
Industrial collaboration	10	12.5	5	10	10	5	5	1	5	P	M	P
Combination of self & group study	10	12.5	5	10	5	1	5	10	5	M	M	M
Highly instructive teacher	10	12.5	10	5	10	10	10	10	10	M	M	M
Study after delivery of lecture	10	12.5	5	5	5	5	5	5	10	M	M	P
One lesson in one lecture	10	12.5	10	5	5	5	5	10	5	M	M	M
Acoustical & Ergonomically improvement	5	6.25	5	5	5	5	1	1	1	S	S	P
Importance			**490**	**510**	**485**	**400**	**505**	**490**	**480**	Lecture Method	Discussion Method	Demonstration Method
% Importance			**14.58**	**15.18**	**14.43**	**11.90**	**15.02**	**14.58**	**14.28**			

10= Strong; **5**= Medium; **1**= Low relationship

M= Mostly satisfied

P= Partially satisfied

S=Slightly satisfied

Figure. 1. Quality function deployment.

3.2. Framework of Designing the Appropriate Teaching Method

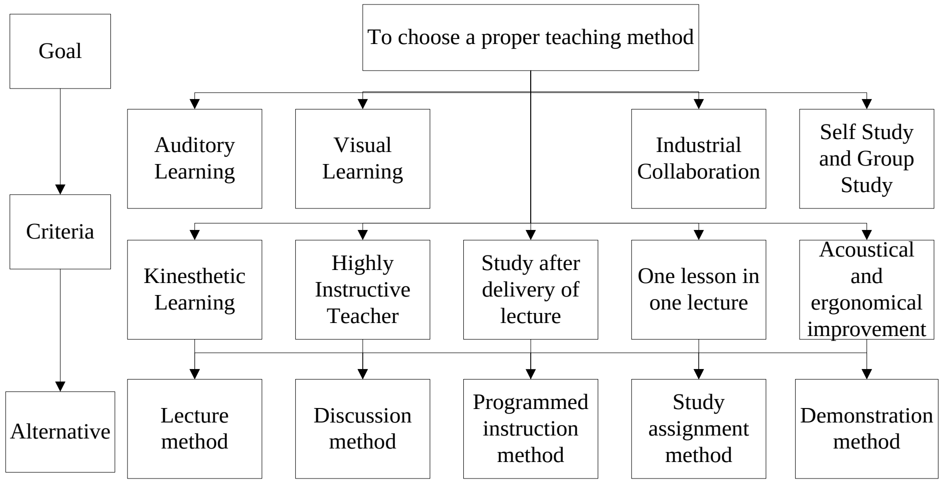


Figure. 2. Framework.

Table 1. Linguistic terms for alternative ratings.

Linguistic term	Membership function
Very poor (VP)	(1, 1, 3)
Poor (P)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very good (VG)	(7, 9, 9)

Table 2. Linguistic terms for criteria ratings.

Linguistic term	Membership function
Very low (VL)	(1, 1, 3)
Low (L)	(1, 3, 5)
Medium (M)	(3, 5, 7)
High (H)	(5, 7, 9)
Very High (VH)	(7, 9, 9)

The Distance between Fuzzy Triangular Numbers. Let a = (a_1, a_2, a_3) and b = (b_1, b_2, b_3,) be two triangular fuzzy numbers. The distance between them is given using the vertex method by

$$d\,(a, b) = \sqrt{1/3[(a_1 - b_1)2 + (a_2 - b_2)2 + (a_3 - b_3)2}. \qquad \textbf{\textit{(1)}}$$

Linguistic Variables. In fuzzy set theory, conversion scales are applied to transform the linguistic terms into fuzzy numbers. In this paper, we will apply a scale of 1–9 for rating the criteria and the alternatives. ***Table 1*** presents the linguistic variables and fuzzy ratings for the alternatives and ***Table 2*** presents the linguistic variables and fuzzy ratings for the criteria.

The Proposed Framework for Choosing Proper Teaching Method. The proposed framework for choosing proper teaching method comprises four steps. These steps are presented in detail as follows:

Table 3. Criteria for teaching method selection.

Symbol	Criteria	Brief Description
C_1	auditory learning	Learning through listening ,speaking & group discussion
C_2	visual learning	Learning through pictures , diagrams & videos
C_3	kinesthetic learning	Learning using physical objects
C_4	industrial collaboration	Practical applications of subjective knowledge
C_5	Combination of self-study & group study	Self-study and group study will be held together
C_6	highly instructive teacher	Wants teacher to teach in a strategy to reduce complexity
C_7	Study after delivery of lecture	Students will study after the delivery of lecture
C_8	One lesson in one lecture	One specific topic will be discussed in one lecture
C_9	Acoustical & ergonomically improvement	Seating arrangements, sound system and other classroom facilities should be improved

Selection of Student Criteria. ***Step 1*** involves the selection of student criteria for evaluating potential method for choosing proper teaching method .These criteria are obtained from literature review, and discussion with teachers and students and survey. 9 criteria are finally chosen to determine the best teaching method. These criteria are shown in ***Table 3***.

Selection of Potential Criteria. ***Step 2*** involves selection of potential criteria for implementing teaching method. The decision makers use their knowledge, prior experience with the conditions of the system to identify candidate teaching method for implementing the best one.

Criteria Evaluation Using Fuzzy TOPSIS. The third step involves evaluation of potential criteria against the selected criteria (***Table 3***) using the technique called fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation). The TOPSIS approach chooses the alternative that is closest to the positive ideal solution and farthest from the negative ideal solution. A positive ideal solution is composed of the best performance values for each attribute whereas the negative ideal solution consists of the worst performance values. Fuzzy TOPSIS has been applied to facility location problems. The various steps of fuzzy TOPSIS are presented as follows:

Step 1. Assignment of Ratings to the Criteria and the Alternatives. Let us assume there are J possible candidates called $A = \{A_1, A_2, . . . ,Aj\}$ which are to evaluated against m criteria, $C= \{C_1, C_2, . . . , C_m\}$. The criteria weights are denoted by w_i ($i = 1, 2 . . . m$). The performance ratings of each decision maker D_k ($k = 1, 2, . . . , K$) for each alternative A_j($j = 1, 2, . . . , n$) with respect to criteria C_i ($i = 1, 2, . . . ,m$) are denoted by $R_k= x_{ijk}$ ($i = 1, 2, . . . ,m; j = 1, 2, . . . , n; k = 1, 2, . . . , K$) with membership function $\mu_{Rk}(x)$.

Step 2. Compute Aggregate Fuzzy Ratings for The Criteria and the Alternatives. If the fuzzy ratings of all decision makers are described as triangular fuzzy numbers

$R_k = (a_k, b_k, c_k)$, k = 1, 2. . . K Then the aggregated fuzzy rating is given by R = (a, b, c), k = 1, 2. . . K, where,

$$a = \min_k\{a_k\}, \quad b = \frac{1}{k}\sum_{k=1}^{k} b_k, \quad c = \max_k c_k . \qquad \textbf{(3)}$$

If the fuzzy rating and importance weight of the kth decision maker are $x_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $w_{ijk} = (w_{jk1}, w_{jk2}, w_{jk3})$, i = 1, 2. . . m, j = 1, 2, . . . n, respectively, then the aggregated fuzzy ratings (x_{ij}) of alternatives with respect to each criterion are given by $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$ where

$$a_{ij} = \min_k\{a_{ijk}\}, \quad b_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ijk}, \quad c_{ij} = \max_k c_{ijk}. \qquad \textbf{(4)}$$

The aggregated fuzzy weights (w_{ij}) of each criterion are calculated as $w_j = (w_{j1}, w_{j2}, w_{j3})$ where

$$w_{j1} = \min_k\{w_{jk1}\}, \quad w_{j2} = \frac{1}{k}\sum_{k=1}^{k} w_{jk2}, \quad w_{j3} = \max_k w_{jk3}. \qquad \textbf{(5)}$$

Step 3. Compute the Fuzzy Decision Matrix. The fuzzy decision matrix for the alternatives (D) and the criteria (W) is constructed.

Step 4. Normalize the Fuzzy Decision Matrix. The raw data are normalized using a linear scale transformation to bring the various criteria scales onto a comparable scale. The normalized fuzzy decision matrix ˜R is given by

$$R = [r_{ij}]_{m\times m}, \quad i= 1, 2 \ldots m; \quad j= 1, 2, \ldots n \quad \text{where,} \quad r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = \max_k c_{ij}.$$

Step 5. Compute the Weighted Normalized Matrix. The weighted normalized matrix V for criteria is computed by multiplying the weights (w_j) of evaluation criteria with the normalized fuzzy decision matrix r_{ij}:

$$V = [v_{ij}]_{m\times m}, \quad i= 1, 2, \ldots m; \quad j = 1, 2, \ldots n \quad \text{where} \quad v_{ij} = r_{ij} \times w_j.$$

Step 6. Compute the Fuzzy Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS). The FPIS and FNIS of the alternatives are computed as follows:

$$A^* = (v_1^*, v_2^*, \ldots v_n^*) \quad v_j^* = \max_i v_{ij3} \quad i = 1, 2 \ldots m; \quad j = 1, 2, \ldots, n.$$

Step 7. Compute the Distance of Each Alternative from FPIS and FNIS. The distance (d_i^*, d_i^-) of each weighted alternative i = 1, 2, . . . ,m from the FPIS and the FNIS is computed as follows:

$$d_j^* = \sum_{j=1}^{n} d_v(v_{ij}, v_j^*) \qquad d_i^- = \sum_{j=1}^{n} d_v(v_{ij}, v_j^-)\ ; \quad i=1.2\ldots m.$$

Where $d_v(a, b)$ is the distance measurement between two fuzzy numbers a and b.

Step 8. Compute the Closeness Coefficient (CC_i) of Each Alternative. The closeness coefficient CC_i represents the distances to the fuzzy positive ideal solution (A^*) and the fuzzy negative ideal solution (A^-) simultaneously. The closeness coefficient of each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^- + d_j^*} \text{ , } i = 1.2. \dots .m.$$

Step 9. Rank the Alternatives. Rank the alternatives according to the closeness coefficient (CC_i) in decreasing order and select the alternative with the highest closeness coefficient for final implementation. The best alternative is closest to the FPIS and farthest from the FNIS.

Numerical Illustration. In this numerical illustration the decision makers have provided linguistic assessments for the nine criteria using rating scales given in ***Table 1*** and to the five alternatives for each of the 9 location criteria using rating scales of ***Table 2***. ***Tables 4*** and ***5*** present the linguistic assessments for the criteria and the alternatives.

Table 4. Linguistic assessments for the five alternatives**.**

Criteria	Alternative	D_1	D_2	D_3	Criteria	Alternative	D_1	D_2	D_3	Criteria	Alternative	D_1	D_2	D_3
C_1	A_1	G	VG	G	C_4	A_1	G	G	F	C_7	A_1	G	VG	G
	A_2	VG	VG	G		A_2	VG	G	G		A_2	VG	VG	G
	A_3	F	G	P		A_3	F	G	P		A_3	F	G	P
	A_4	G	G	F		A_4	P	P	P		A_4	G	F	F
	A_5	F	F	G		A_5	G	VG	G		A_5	F	F	G
C_2	A_1	G	G	F	C_5	A_1	VG	G	G	C_8	A_1	VG	G	G
	A_2	VG	G	G		A_2	VG	G	G		A_2	VG	VG	G
	A_3	G	P	P		A_3	G	F	F		A_3	G	F	F
	A_4	G	P	P		A_4	F	P	F		A_4	F	G	G
	A_5	P	P	P		A_5	P	F	F		A_5	P	P	P
C_3	A_1	F	G	G	C_6	A_1	G	VG	VG	C_9	A_1	F	G	G
	A_2	P	P	F		A_2	VG	VG	VG		A_2	P	VP	P
	A_3	F	P	P		A_3	F	G	F		A_3	F	P	P
	A_4	P	F	P		A_4	G	G	F		A_4	P	F	F
	A_5	VG	VG	G		A_5	F	G	F		A_5	G	G	G

Table 5. Aggregate fuzzy weight for criteria.

Criteria	D_1	D_2	D_3	Aggregated fuzzy weight
C_1	(7,9,9)	(5,7,9)	(7,9,9)	(5,8.33,9)
C_2	(7,9,9)	(7,9,9)	(5,7,9)	(5,8.33,9)
C_3	(5,7,9)	(5,7,9)	(7,9,9)	(5,7.66,9)
C_4	(5,7,9)	(7,9,9)	(7,9,9)	(5,8.33,9)
C_5	(5,7,9)	(3,5,7)	(3,5,7)	(3,5.66,9)

Criteria	D_1	D_2	D_3	Aggregated fuzzy weight
C_6	(5,7,9)	(5,7,9)	(3,5,7)	(3,6.33,9)
C_7	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
C_8	(3,5,7)	(5,7,9)	(7,9,9)	(3,7,9)
C_9	(3,5,7)	(5,7,9)	(5,7,9)	(3,6.33,9)

Then, the aggregated fuzzy weights for each criterion are calculated. The aggregate weights of the 9 criteria are presented in ***Table 6***.

Table 6. Aggregate fuzzy weight for alternatives.

Criteria	Alternatives	D_1	D_2	D_3	Aggregate ratings
C_1	A_1	(5,7,9)	(7,9,9)	(5,7,9)	(5,7.66,9)
	A_2	(7,9,9)	(7,9,9)	(5,7,9)	(5,8.33,9)
	A_3	(3,5,7)	(5,7,9)	(1,3,5)	(1,5,9)
	A_4	(5,7,9)	(5,7,9)	(3,5,7)	(3,6.33,9)
	A_5	(3,5,7)	(3,5,7)	(5,7,9)	(3,5.66,9)
C_2	A_1	(5,7,9)	(5,7,9)	(3,5,7)	(3,6.33,9)
	A_2	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
	A_3	(5,7,9)	(1,3,5)	(1,3,5)	(1,4.33,9)
	A_4	(5,7,9)	(1,3,5)	(1,3,5)	(1,4.33,9)
	A_5	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)
C_3	A_1	(3,5,7)	(5,7,9)	(5,7,9)	(3,6.33,9)
	A_2	(1,3,5)	(1,3,5)	(3,5,7)	(1,3.66,7)
	A_3	(3,5,7)	(1,3,5)	(1,3,5)	(1,3.66,7)
	A_4	(1,3,5)	(3,5,7)	(1,3,5)	(1,3.66,7)
	A_5	(7,9,9)	(7,9,9)	(5,7,9)	(5,8.33,9)
C_4	A_1	(5,7,9)	(5,7,9)	(3,5,7)	(3,6.33,9)
	A_2	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
	A_3	(3,5,7)	(5,7,9)	(1,3,5)	(1,5,9)
	A_4	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)
	A_5	(5,7,9)	(7,9,9)	(5,7,9)	(5,7.66,9)
C_5	A_1	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
	A_2	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
	A_3	(5,7,9)	(3,5,7)	(3,5,7)	(3,5.66,9)
	A_4	(3,5,7)	(1,3,5)	(3,5,7)	(1,4.33,7)
	A_5	(1,3,5)	(3,5,7)	(3,5,7)	(1,4.33,7)
C_6	A_1	(5,7,9)	(7,9,9)	(7,9,9)	(5,8.33,9)
	A_2	(7,9,9)	(7,9,9)	(7,9,9)	(7,9,9)
	A_3	(3,5,7)	(5,7,9)	(3,5,7)	(3,5.66,9)
	A_4	(5,7,9)	(5,7,9)	(3,5,7)	(3,6.33,9)
	A_5	(3,5,7)	(5,7,9)	(3,5,7)	(3,5.66,9)
C_7	A_1	(5,7,9)	(7,9,9)	(5,7,9)	(5,7.66,9)
	A_2	(7,9,9)	(7,9,9)	(5,7,9)	(5,8.33,9)
	A_3	(3,5,7)	(5,7,9)	(1,3,5)	(1,5,9)
	A_4	(5,7,9)	(3,5,7)	(3,5,7)	(3,5.66,9)
	A_5	(3,5,7)	(3,5,7)	(5,7,9)	(3,5.66,9)
C_8	A_1	(7,9,9)	(5,7,9)	(5,7,9)	(5,7.66,9)
	A_2	(7,9,9)	(7,9,9)	(5,7,9)	(5,8.33,9)
	A_3	(5,7,9)	(3,5,7)	(3,5,7)	(3,5.66,9)
	A_4	(3,5,7)	(5,7,9)	(5,7,9)	(3,6.33,9)
	A_5	(1,3,5)	(1,3,5)	(1,3,5)	(1,3,5)
C_9	A_1	(3,5,7)	(5,7,9)	(5,7,9)	(3,6.33,9)
	A_2	(1,3,5)	(1,1,3)	(1,3,5)	(1,2.33,5)
	A_3	(3,5,7)	(1,3,5)	(1,3,5)	(1,3.66,7)
	A_4	(1,3,5)	(3,5,7)	(3,5,7)	(1,4.33,7)
	A_5	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)

Then, the aggregate fuzzy weights of the alternatives are computed.

In the next step, we perform normalization of the fuzzy decision matrix of alternatives. This is presented in ***Table 7***.

Table 7. Normalized fuzzy decision matrix for alternatives.

Criteria	c_j^*	A_1	A_2	A_3	A_4	A_5
C_1	9	(.56,.85,1)	(.56,.93,1)	(.11,.56,1)	(.33,.70,1)	(.33,.63,1)
C_2	9	(.33,.70,1)	(.56,.85,1)	(.11,.48,1)	(.11,.48,1)	(.11,.33,.56)
C_3	9	(.33,.70,1)	(.11,.48,1)	(.11,.48,1)	(.11,.48,1)	(.56,.93,1)
C_4	9	(.33,.70,1)	(.56,.85,1)	(.11,.56,1)	(.11,.33,.56)	(.56,.85,1)
C_5	9	(.56,.85,1)	(.56,.85,1)	(.33,.63,1)	(.11,.48,.78)	(.11,.48,.78)
C_6	9	(.56,.93,1)	(.78,1,1)	(.33,.63,1)	(.33,.70,1)	(.33,.63,1)
C_7	9	(.56,.85,1)	(.56,.93,1)	(.11,.56,1)	(.33,.63,1)	(.33,.63,1)
C_8	9	(.56,.85,1)	(.56,.93,1)	(.33,.63,1)	(.33,.70,1)	(.11,.33,.56)
C_9	9	(.33,.70,1)	(.11,.26,.56)	(.11,.41,.78)	(.11,.48,.78)	(.56,.78,1)

Then, the fuzzy weighted decision matrix for the five alternatives is constructed. The r_{ij} values from ***Table 8*** and w_{ij} values from ***Table 6*** are used to compute the fuzzy weighted decision matrix for the alternatives.

Table 8. Weighted normalized alternatives, FPIS and FNIS.

Criteria	A_1	A_2	A_3	A_4	A_5	FPIS(A^*)	FPNS(A^-)
C_1	(2.8,7.1,9)	(2.8,7.75,9)	(1.65,4.66,9)	(1.65,5.83,9)	(1.65,5.25,9)	(9,9,9)	(1.65,1.65,1.65)
C_2	(1.65,5.83,9)	(2.8,7.1,9)	(.55,3.99,9)	(.55,3.99,9)	(.55,2.75,5.04)	(9,9,9)	(.55,.55,.55)
C_3	(1.65,5.36,9)	(.55,3.14,7.02)	(.55,3.14,7.02)	(.55,3.14,7.02)	(2.8,7.12,9)	(9,9,9)	(.55,.55,.55)
C_4	(1.65,5.83,9)	(2.8,7.08,9)	(.55,4.66,9)	(.55,2.75,5.04)	(2.8,7.08,9)	(9,9,9)	(.55,.55,.55)
C_5	(1.68,4.81,9)	(1.68,4.81,9)	(.99,3.57,9)	(.33,2.72,7.02)	(.33,2.72,7.02)	(9,9,9)	(.33,.33,.33)
C_6	(1.68,5.89,9)	(2.34,6.33,9)	(.99,3.99,9)	(.99,4.43,9)	(.99,3.99,9)	(9,9,9)	(.99,.99,.99)
C_7	(2.8,6.51,9)	(2.8,7.12,9)	(.55,4.23,9)	(1.65,4.83,9)	(1.65,4.83,9)	(9,9,9)	(.55,.55,.55)
C_8	(1.68,5.95,9)	(1.68,6.51,9)	(.99,4.41,9)	(.99,4.9,9)	(.33,2.31,5.04)	(9,9,9)	(.33,.33,.33)
C_9	(.99,4.43,9)	(.33,1.65,5.04)	(.33,2.60,7.02)	(.33,3.04,7.02)	(1.68,4.94,9)	(9,9,9)	(.33,.33,.33)

Then, we compute the distance $d_v(.)$ for each alternative from the fuzzy positive ideal matrix (A^+) and fuzzy negative ideal matrix ($A-$).

Table 9. Distances for alternatives**.**

Criteria	$d_v(A_1,A^-)$	$d_v(A_2,A^-)$	$d_v(A_3,A^-)$	$d_v(A_4,A^-)$	$d_v(A_5,A^-)$	$d_v(A_1,A^+)$	$d_v(A_2,A^+)$	$d_v(A_3,A^+)$	$d_v(A_4,A^+)$	$d_v(A_5,A^+)$
C_1	5.32	5.55	4.59	4.88	4.73	3.74	3.65	4.93	4.62	4.76
C_2	5.79	6.31	5.27	5.27	2.89	4.62	3.74	5.67	5.67	6.48
C_3	5.65	4.02	4.02	4.02	6.31	4.73	6.05	6.05	6.05	3.74
C_4	5.79	6.30	5.43	2.89	6.30	4.62	3.75	5.48	6.48	3.75
C_5	5.69	5.69	5.36	4.10	4.10	4.87	4.87	5.59	6.29	6.29
C_6	5.44	5.61	4.94	5.03	4.94	4.59	4.14	5.45	5.32	5.45
C_7	6.11	6.31	5.32	5.51	5.51	3.86	3.74	5.60	4.87	4.88
C_8	6.02	6.20	5.55	5.67	2.95	4.58	4.46	5.33	5.20	6.72
C_9	5.55	2.82	4.08	4.17	5.72	5.32	6.95	6.33	6.18	4.83

Table 10. Closeness coefficients (CCi) of the five alternatives.

	A_1	A_2	A_3	A_4	A_5	Ranking order
d_i^-	51.36	48.81	44.56	41.54	43.45	
d_j^*	40.93	41.35	50.43	50.68	46.90	$A_1 > A_2 > A_5 > A_3 > A_4$
CC_i	0.5565	0.5432	0.4691	0.4504	0.4809	

By comparing the CCi values of the five alternatives (***Table 10***), we find that $A_1 > A_2 > A_5 > A_3 > A_4$. Therefore, location A_1 is selected as the best teaching method.

5. Proposed Method

A multi-criteria method for teaching method under a fuzzy environment. Fuzzy TOPSIS is used to determine aggregate scores for all teaching methods and the one with the highest score is finally chosen for implementation. But it is found that highest score i.e. Lecture method is very close to the immediate next score i.e Discussion method. So we consider these two methods. As the two methods has their own characteristics, we derived a totally new method from two methods that will be completely satisfying the students requirements which found from survey.

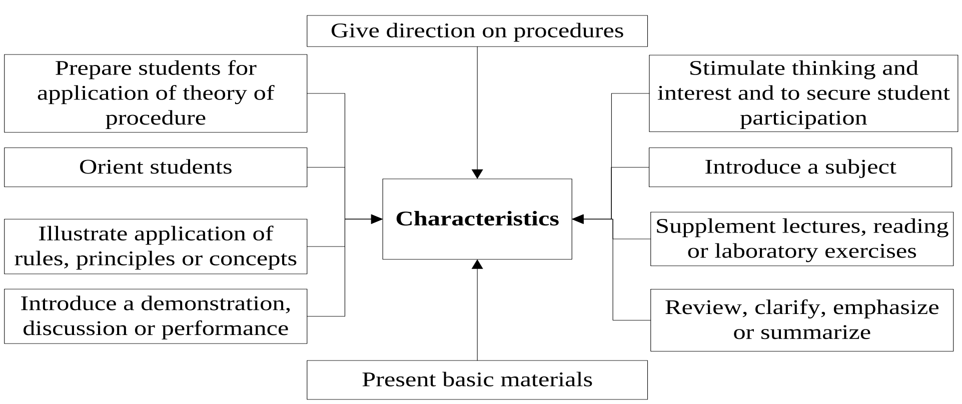


Figure 3. Proposed method characteristic.

6. Conclusion

Our main concern was to design a proper teaching method which will fulfill the student's criteria and teachers recommendations. At first we have found the student criteria by the survey among the students and teachers to get their recommendations. Then we have applied QFD for ranking the students criteria and presented a multi-criteria method for selecting an effective teaching method under a fuzzy environment. Fuzzy TOPSIS was used to determine aggregate scores for all teaching methods and the one with the highest score was finally chosen for implementation. But it was found that highest score is very close to the immediate next score. So we considered that two methods. We derived a recommended method from two methods that was quite satisfying the students requirements which we found from survey.

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