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Article

Evaluating E-Teaching Adoption Criteria for Indian Educational Organizations Using Fuzzy Delphi-TOPSIS Approach

Tsun-Yu Huang [1], Wen-Kuo Chen [1], Venkateswarlu Nalluri [2,]* and Thao-Trang Huynh-Cam [2,3]

1 Department of Marketing and Logistics Management, Chaoyang University of Technology, Taichung 413310, Taiwan; bruce121new@gm.cyut.edu.tw (T.-Y.H.); wkchen@cyut.edu.tw (W.-K.C.)
2 Department of Information Management, Chaoyang University of Technology, Taichung 413310, Taiwan; hcttrang@dthu.edu.vn
3 Informatics and Foreign Languages Center, Dong Thap University, Cao Lãnh City 81118, Vietnam
* Correspondence: t5210341@gm.cyut.edu.tw

Abstract: Due to advances in information and communication technology, e-teaching has become increasingly popular and is in high demand by educational organizations. During the lockdown period of COVID-19 especially, e-teaching provided prior solutions to address the pressing need for monitoring students' learning progress. However, in many developing countries, it is apparent that a wide variety of issues are related to e-teaching adoption. Although the implementation issues associated with e-teaching have been addressed in the existing research literature and in practice for many years, from the available research, the evaluation of e-teaching adoption criteria and ranking using fuzzy theory has been ignored. Therefore, the present research aims to evaluate and rank the criteria for e-teaching adoption through Fuzzy Delphi and Fuzzy TOPSIS. A total of four criteria and twelve sub-criteria for e-teaching adoption were determined based on a systematic literature review and professors' opinions in India. In addition, the Fuzzy Delphi method was employed to finalize the criteria, and the Fuzzy TOPSIS method was employed for ranking the alternatives. The assessment results showed that among the identified alternatives, the "share the technology with other organizations" and "course integration with technology" were the top-ranked alternatives for improving e-teaching adoption. An understanding of these conceptual alternatives can encourage the adoption of e-teaching in educational organizations.

Keywords: e-teaching adoption; e-teaching adoption criteria; Fuzzy Delphi; Fuzzy TOPSIS; educational organizations

MSC: 62A86; 90-XX

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1. Introduction

Due to advances in Information and Communication Technology (ICT), e-teaching is now in high demand from educational organizations (EOs). During the lockdown period of COVID-19 especially, e-teaching provided prior solutions to address the pressing need for monitoring students' learning progress. Teaching environments in particular, with the combination of cutting-edge education technology, such as smartphones, laptops, and tablets with high-speed internet access to the web and/or social media, have significantly changed teaching styles in EOs [1,2]. E-teaching through the use of online-based apps, mobile applications, and different social media portals has been favorable to both educational teams and students due to the ease of use, convenience, quickness, and low costs [3]. With the digital revolution in the education sector, dynamic information and communication knowledge have encouraged transacted physical pedagogics and teaching style by encouraging collaborative e-teaching and e-learning methods [4]. Consequently, every EO is attempting to implement advanced methods to meet online potentials through various teaching strategies such as e-teaching and teaching technologies [5]. These cutting-edge technology-based methods of teaching are mainly developed by decision makers of EOs.

Moreover, the COVID-19 pandemic saw every educational organization shift from in-person teaching to e-teaching or online teaching, offering an easy-to-access knowledge environment and interactive communication opportunities during the period of the COVID-19 pandemic by offering fast and easy access to information via the internet platform [6]. Similarly, the Ministry of Education of India issued a series of policy measures to promote e-teaching/online teaching through its different schemes. The success of those promotional activities has not been quite prominent, but EOs have managed to seek greater visibility in recent five-year plans. Moreover, EOs have recently faced enormous challenges and been under greater pressure to conduct online classes in terms of e-teaching quality assurance. One of the critical aspects of e-teaching is to provide an effective interactive environment for participants. The successful adoption of an e-teaching system or method depends on different criteria. One of the important solutions for decreasing challenges and pressure is to determine and/or evaluate the available criteria for e-teaching adoption. The present education system has gradually lost its place, especially with the time constraints related to physical-style teaching approaches. Furthermore, Internet Technology (IT) has evolved dramatically and a plethora of e-teaching and learning platforms have emerged [7]. Nonetheless, many teaching methods have been rendered ineffective due to a lack of efficiency. Therefore, e-teaching is a modern method that aims to improve education by improving teaching processes in the global pandemic era [8]. However, e-teaching, defined as a creative teaching technique, has attracted expanding attention aimed at overcoming the problems and repute among teachers or professors due to its extensive bid in an education sector arrangement [9]. The most important feature of these systems is that they allow education regardless of time and place. Advanced technology supports the improvement of innovative tools and methods used on these platforms [10]. In this way, these platforms have become an essential part of the education sector in India. The education system includes various stakeholders. Each stakeholder evaluates the sector from their perspective. Here, the teachers and professors are the key stakeholders, conducting online classes to overcome the issues caused by the pandemic [11].

Previous studies have focused on technology adoption in relation to successful online teaching. For instance, Sundqvist et al. [12] analyzed the impact of technology and institutional support on e-teaching adoption in developing nations and assumed that system-level, school-level, and student-level analyses inhibit teachers from using technology in the classroom. In contrast, Basbeth et al. [13] found interpersonal, institutional, technological, and training barriers were perceived as major e-teaching problems in developed countries, especially the USA. Moreover, authors in [14] indicated that faculty considered a lack of training, the size of the organization, and the complexity of the programs as barriers to effective e-teaching in advanced nations. Additionally, Ekinci et al. [15] used Multiple-criteria Decision-making (MCDM) tools from the student's perspective to categorize the factors affecting physical and online teaching. However, from the available literature, a few studies have identified criteria or alternatives for e-teaching adoption; those studies also ignored ranking the criteria systematically for sustainable teaching operations. Second, a few studies have identified the criteria without ranking them appropriately in the context of EOs in India [16]. As a result, understanding the impact of systemic criteria for sustainable teaching operations in their organizations is essential for EOs [17]. It also seems essential to investigate e-teaching adoption in the education sectors in India. Thus, the present research aims to identify important criteria and rank the alternatives that influence the e-teaching adoption method from professors' perspectives.

In order to identify criteria ranking for e-teaching adoption, this study started with determining the criteria and sub-criteria, which are available in the most recent literature. To confirm the sub-criteria, a survey questionnaire was prepared and discussed with professors in India. However, some uncertainties may occur during the decision-making process and may involve stakeholders with different interests [18]. Therefore, this study implemented a combination of Fuzzy-Delphi-TOPSIS methodology to overcome these uncertainties. In addition, an in-depth assessment of factors affecting e-teaching adoption in EOs was applied through the Fuzzy Technique for Order of Preference using the Similarity to Ideal Solution (Fuzzy TOPSIS) approach, which is functionally associated with the problems of discrete alternatives [19]. This TOPSIS technique is one of the most practical methods for solving real-world problems, as it is capable of rapidly identifying the best alternative. Furthermore, the Fuzzy TOPSIS method offers the best alternatives for e-teaching adoption through systematic ranks, which can help EOs to effectively develop strategies for converting physical classes to online classes. Therefore, it seems essential to investigate in the context of e-teaching adoption for education sectors. The present research aims to identify criteria and rank the alternatives that influence the e-teaching adoption method from professors' perspective in India. The objectives were developed as follows: (1) To finalize criteria and sub-criteria for e-teaching adoption by applying the Fuzzy Delphi method. (2) To select the best alternative among available ones by ranking them through the Fuzzy TOPSIS method.

Based on the study results, the primary contribution of the present study was to offer a clear understanding of e-teaching adoption criteria and rank them through the responder's input in the education sector. Such information would help government policymakers and EOs identify the most important alternatives to developing effective strategies for e-teaching adoption in India.

The following is the order of this paper's structure. Section 2 presents a systematic literature review including e-teaching approaches, e-teaching adoption, and the applications of Fuzzy Delphi and Fuzzy TOPSIS methods. In Section 3, the proposed methodology with Fuzzy-Delphi-TOPSIS tools is expounded upon in detail. In Section 4, the analysis results are demonstrated. Section 5 contains concluding remarks before the reference list.

2. Literature Review

2.1. E-Teaching Approaches

Cao et al. [20] summarized two main teaching approaches: Information Transmission/ Teacher-focused Approach to Teaching (ITTF) and Conceptual Change and Student-focused (CCSF) Approach to Teaching. In the ITTF approach, knowledge was transmitted from teachers to students, whereas in CCSF, teachers helped students develop their own understanding of knowledge. A further study discovered similarities among teaching approaches and concepts in which teachers more likely applied the CCSF approach in their teaching [21]. In addition, those studies categorized the teaching approaches in terms of logical relationships among strategies and intentions and established a systematic relationship between these strategies and intentions. Alternatively, Khan et al. [22] acknowledge approaches as a continuum of aspects in terms of strategies and motivation, rather than intentions. On the other hand, Alt [23] applied four main characteristics to classify teaching approaches: learning environment, teaching process, learning conception, and pedagogical development. This characterization incorporates "conceptions of learning", which have been determined as a separate aspect of the teaching experience [24], as teachers' current understandings rather than the actual act of teaching as represented by their approaches. Likewise, this classification incorporates elements such as learning environment and pedagogical development that have not before been documented as part of teaching approaches.

Moreover, the mixed e-teaching strategies have attracted many researchers [25]. Particularly, Oyedotun, [26] focused on a phenomenon graphic perspective; her research outcomes to "teaching via the web" seemed to be more closely related to the assessment made by Tseng et al. [27]: instead of a hierarchy of logically interconnected categories of description, aspects were expressed as a continuum. In spite of this concern, Schmidt [28] discussed ITTF approaches ranging from student-focused to technology-focused. One significant distinction among these approaches is that the first focus is on the technology itself, which was used to manage student activities or to experiment with different types of new technology. In another case, the emphasis here is on how to use educational technology to enhance and assist teaching. Positive and relevant relationships have been found among student-focused methods to technology-focused approaches and teaching as design, which focuses on building activities and tasks to encourage learning quality. Significantly strong relationships have been found among these approaches and perceptions of teaching methods aimed at assisting student learning. It is worth noting two problems that have emerged from research on e-teaching approaches and their adoption in India. First, there are some issues with how e-teaching has been conceptualized. Richardson et al. [24] analyzed e-teaching factors for face-to-face and online teaching. Second, there is no unified terminology for referring to different approaches. In the meantime, Naylor [5] invented approaches ranging from knowledge building-focused to information-focused; Graham and Pottie-Sherman [29] described approaches ranging from student-focused to technology-focused. In addition, further studies have been focused on knowledge-focused and student-focused approaches that appear to be quite similar to the present author's explanations [6]. In both instances, integrating technology aims to create environments where students gain knowledge on reasoning skills and critical thinking. Although Sepasgozar [30] emphasizes the web for managing teachers' activities and experimenting with new technology. Thus, these less sophisticated classifications do not appear to be identical. This suggests that despite current research on teaching approaches, no unified nomenclature has been developed for understanding the e-teaching approach.

2.2. E-Teaching Adoption Context

E-teaching is not the same as conventional teaching, nor is it a transfer from traditional pedagogy. The biggest issue for EOs in India was to deploy technology for e-teaching in a short time during the COVID-19 pandemic. They were also compelled to undertake their examinations over the internet, which further escalated their difficulties. In practice, many teachers and professors reported that holding classes from the home environment was stressful and demotivating. However, studies on the difficulties associated with e-learning during the COVID-19 pandemic are more focused, for example, research on difficult issues, such as those faced by teachers regarding internet access. For instance, Basbeth et al. [13] found that teachers and professors were suffering during the lockdown period. Gratz and Looney [31] also conducted that faculty members revealed a lack of internet and computer skills, although they were willing to teach online classes. Moreover, Mushtaq et al. [14] asserted difficulties associated with training, technology, and engaging students in order to maintain academic performance during the epidemic.

According to the international education system development authority (IESDA) survey, one of the major reasons for ineffective e-teaching systems is that the technological infrastructure has not yet reached a level of quality for effective e-class delivery, especially in India. Teachers lacked adequate infrastructure, such as internet access, microphones, and laptops to quickly and effectively disseminate education. Several teachers were faced with technical problems, bandwidth problems, failure of the system, and other technical issues. They were unable to resolve problems while conducting e-classes due to a lack of technical assistance. Another difficulty was that several EOs lack trained teachers and professors who can work remotely via internet platforms; therefore, they found it difficult to accept the transition [32]. In addition, teachers in government-oriented institutions were given ambiguous guidelines and orders to start classes from their residences. Authors in [18] anticipated older teachers would not have the technical skills needed to conduct online classes. Moreover, the authors in [27] determined that handling the students in virtual teaching was an extremely challenging task. Students were purposefully generating indiscipline by making noise, playing games, posting negative comments through bogus users, and listening to music [27].

Therefore, it is essential to investigate the adoption of e-teaching issues from the professors' perceptions to develop systematic guidelines for improving the quality of e-teaching systems for EOs. However, from the available literature review, no studies have been conducted from a contextual perspective that systematically explore criteria or sub-criteria for e-teaching adoption. Additionally, no studies have implemented a proper investigation in the context of India. Hence, the current study implemented research on these associations.

2.3. Applications of Fuzzy Delphi and Fuzzy TOPSIS Methods

The MCDM method was introduced in the early 19th century and faced criticism for convergence, uncertainty, and vagueness of responders' inputs initiated by the repetitive survey. Simić et al. [33] suggested overcoming these drawbacks by integrating the Fuzzy set. Later, Abdel-Basset et al. [34] modified the technique with fuzzy numbers and presented the Fuzzy Delphi Method (FDM). Authors in [35] recently employed the Fuzzy theory to capture uncertainty in measuring the criteria of sustainability in the financial sector. Furthermore, scholars have proposed integrating Fuzzy logic with MCDM methods to provide improved accuracy in complex decision making issues, such as Fuzzy DEMATEL for the causal relationship among barriers to implementing education 4.0 practices, which were examined in [36], Fuzzy AHP for factors influencing cloud computing adoption for higher educational institutes in India, evaluated in [37] and Fuzzy TOPSIS for prioritization of students' requirements in higher education institutions, investigated in [38]. Authors in [39] combined FDM and Fuzzy TOPSIS to handle the uncertainty of system selection in the banking sector. Additionally, Anshu and Gaur [40] employed Fuzzy TOPSIS to address online education satisfaction assessment based on the cloud model in the education sector. However, from the existing studies, no research integrates FDM with TOPSIS to rank the criteria for e-teaching in EOs. Thus, this study utilized the combination of FDM and Fuzzy TOPSIS to identify important criteria and rank the alternatives for e-teaching adoption.

Based on the present literature, the Fuzzy TOPSIS technique was distinguished by the fact that it is the classic multi-standard decision model (MSDM) and requires precise standard weights [41]. However, in many studies, clear data are not sufficient to simulate real-world situations because human judgment is often vague and cannot be estimated with accurate values [42]. Language variables are the natural manifestation of subjective judgment and the preferences of experts in a structured manner. By measuring this essential fuzziness of the subjective judgment of experts, Fuzzy Set Theory (FST) provides suitable tools to adapt to uncertain and complex environments, thus reducing the fuzziness of the results. Many current studies successfully used the FST to measure the fuzziness of concepts related to human judgment. The order performance tool was similar to the ideal solution [16], which is one of the classical MCDM approaches. The selected alternative should be kept as close to the positive ideal solution as possible, i.e., the closest to the fuzzy positive ideal solution (FPIS); and as far away from negative ideal solutions as possible, i.e., the farthest from the Fuzzy negative ideal solution (FNIS) [43]. Various other MCDM methods were applied by previous studies [23,36,41], such as a performance value analysis (PVA), analytical hierarchy process (AHP), and electron method. In general, the MCDM tools PVA is unacceptable, which is used to discard some alternatives to the problem, whereas the AHP has its limitations, while the standards are large and time-consuming. In addition, the electron method is unacceptable, because in some certain cases, it may be used to discard some alternatives to the problem. Therefore, the Fuzzy TOPSIS was employed in the present study not only because it uses linguistic teams to evaluate the standard rating conveniently and reasonably to express opinions, but also because it can be applied to the model of decision-making criteria for sorting real-world problems [30]. Moreover, the hybrid approaches are a systematic understanding and analytical method for defining aspects or criteria that occur in the education system with Fuzzy theory, which was used by Onu et al. [44]. Theoretically, e-teaching is regarded as a highly complex method of teaching that includes several interdependent criteria and alternatives. Consequently, Olugu et al. [45] presented study models that failed to account for ranking these criteria. Therefore, this study proposed a methodology involving a combination of Fuzzy-Delphi-TOPSIS. In addition to Fuzzy-Delphi-TOPSIS, both applications seemed to be effective methods for identifying and ranking the criteria within the system [37].

3. Methodology

This section describes the process of a proposed methodology for evaluating and ranking the e-teaching adoption criteria from professors' perspectives in India. The research process was divided into three prominent phases as shown in Figure 1. In Phase 1, a systematic literature review was conducted to determine the criteria and sub-criteria. In Phase 2, the Fuzzy Delphi method was applied to confirm and finalize the sub-criteria. In Phase 3, the Fuzzy TOPSIS method was used to analyze and rank the alternatives to e-teaching adoption. This study interpreted the preceding, conditions were interpreted and then a Fuzzy hybrid methodology was proposed based on the combination of Fuzzy Delphi and Fuzzy TOPSIS to examine the e-teaching adoption criteria in the education sector.

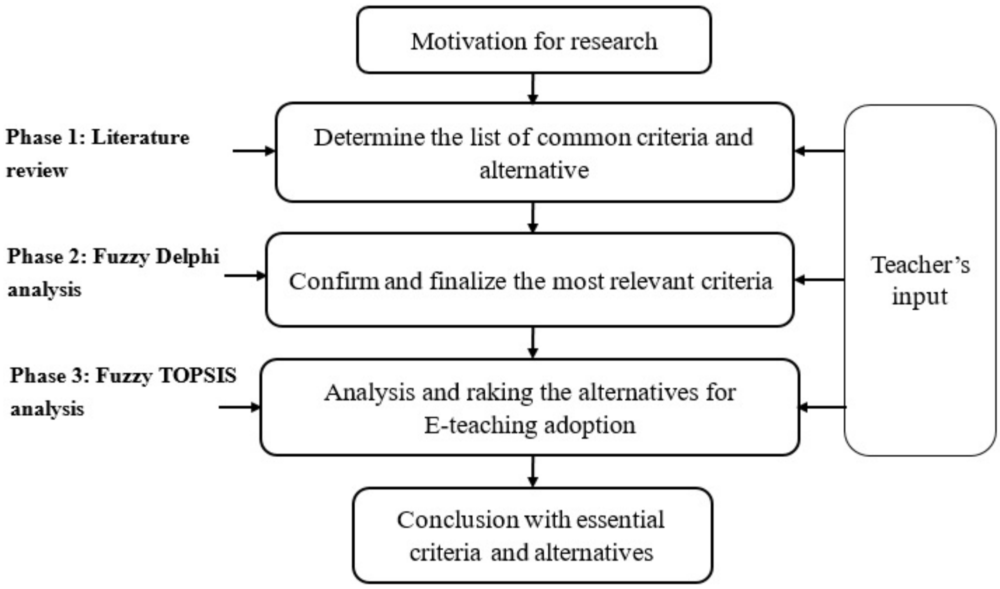

Figure 1. Proposed research process.

3.1. Data Collection

In India, the Right of Children to Free and Compulsory Education Act was introduced in 2009, which was responsible for the development of children's education in society. Nowadays, the education system is one of the key areas for the growth of India. The education and information technology sectors have contributed significantly to this country's economic growth with the help of different public and private organizations. In 2021, the Indian literacy rate was determined as 81.1%; although evidence shows that online education services in India are growing, these services are only provided in a few of the private and public EOs. In addition, a small number of major EOs solely offer e-teaching services that other organizations are not providing due to several issues. This study focused on the four criteria for e-teaching adoption by EOs. However, in the present literature, Chen et al. [46] weighed the criteria for assessing candidates for division manager using less than ten responders, whereas Sagnak et al. [47] analyzed sustainable collection and center location selection using around 30 inputs from the industry. In addition, Gupta [48] noted the major advantage of using TOPSIS was the requirement of less data points from experts such as criteria weights and linguistic preference of alternatives.

Therefore, the target population of this research comprises the professors and teachers of EOs in India. All details of responders are noted in Table 1. In addition, we randomly selected those EOs which do not provide classes through internet platforms to the students. Data collection was conducted in four cities in India: Delhi, Bangalore, Hyderabad, and Guntur. Here, the authors used their personal and research collaboration contacts in the data collection process. Furthermore, our survey is reliable and valid, as it contains questions covering all aspects of the construct being measured and our measurements are consistent from individual to individual, surveyed across settings and at different times.

From this table, it was found that the majority of the responders had worked as teachers or professors for 5–10 years in their current organizations. In addition, all respondents had graduate degrees from well-known Indian business schools and universities. The dataset of this study was collected throughout several phases using a set of questionnaires through an electronic questionnaire survey (EQS). The EQS was sent to Indian professors via their email in order to avoid unauthorized and duplicated responses. The responders were asked to give a rating on a scale of one to five, i.e., very high, high, medium, low, and very low with scores of 5, 4, 3, 2, and 1, respectively, in Phase 2. Furthermore, these responses were assessed the criteria and sub-criteria, using fuzzy scale for Fuzzy TOPSIS analysis in Phase 3. A few common responses were given for both phase questionnaires. According to the responder's evaluation, this research recognizes and ranks the criteria and sub-criteria for e-teaching adoption by using Fuzzy Delphi-TOPSIS methods.

Table 1. Assessment of responders in the data collection process.

Phase	Sample Size	Responders Characteristics							Purpose of the Data Collection
		Organization Type		Education Level	Work Experience				
		Schools	Universities		Career Experience (Years)		At Present Organization		
2	36	12	24	Graduated	<5 5–10 >10		08 16 12	19 17 00	To confirm and finalize criteria and sub-criteria.
3	27	09	18	Post graduated	<5 5–10 >10		02 14 11	05 16 06	To assign a rank for sub-criteria.

Table 1 lists the assessment of responders in the data collection process through an online questionnaire survey. Out of 47 responders, 36 usable responses were selected for further analysis, resulting in a 76.59% response rate. The remaining 18% of responses containing missing information were excluded from this study.

3.2. Fuzzy Theory

This section describes the Fuzzy Delphi method, deduction process, fuzzy logic, and TOPSIS analysis steps.

3.2.1. Fuzzy Delphi Method

In Phase 1, an initial set of criteria and sub-criteria for e-teaching adoption in the education system were determined through an extensive systematic review of the literature. In Phase 2, the Fuzzy Delphi method (FDM) was employed in the initial list of sub-criteria in order to select the most relevant ones and to finalize the criteria following the distribution of a questionnaire to educational institution respondents in India. FDM was used to obtain a collective conclusion by reducing the fuzziness of expert judgments, which improved the usefulness and reliability of questionnaires [46]. In addition, FDM can reduce sample size and research time, and offer a clearer expression of the decision makers knowledge. In other words, expert opinions can also be reshaped into quantifiable data using the FDM to produce extra benefits and satisfy requirements in terms of time and cost judgment. Thus, the FDM was revised to determine sub-criteria of e-teaching adoption based on the responder's assessment from the education sector. This computation was generated from calculating the minimum (MIN), median, and maximum (MAX) values using an Excel sheet. Then, the fuzzy values were transferred as defuzzification values using Equation (1).

$$\text{Defuzzification value} = \frac{\text{MIN} + (4 * \text{Median}) + \text{MAX}}{6} \tag{1}$$

3.2.2. Deduction Process

The deduction process was used to subtract the important sub-criteria for e-teaching adoption. This process determines the appropriate sub-criteria before applying the Fuzzy TOPSIS method. Adoption factors are alternative paths by which e-teaching adoption can be improved in India, whereas sub-criteria are standards or a set of rules that can be used to evaluate these possibilities and make a judgment/decision. However, the responses to the deduction process for sorting the e-teaching adoption factors were transformed into percentages, with the threshold percentage for deduction processes set at 75% [42]. It was calculated by subtracting the difference between the mode and the lowest percentage for each criteria group's [Yes] and [No] responses and divided into four groups such as Technological issues, Institutional issues, Teacher's readiness, and Environmental issues.

3.2.3. Fuzzy Logic

The fuzzy linguistic terms used as very high, high, median, low, and very low with numerical value of 5, 4, 3, 2, and 1. In addition, the scale of triangular fuzzy is (0.75,1.00,1.00), (0.50,0.75,1.00), (0.25,0.50,0.75), (0,0.25,0.50), and (0,0,0.25), respectively. Moreover, fuzzy design questionnaires were administered to acquire data on the performances with regard to deducted sub-criteria, and the fuzzy linguistic scales (as noted above) were utilized to create the decision matrix with factors A_i, SC_i, and Z_{ij} (Table 2).

Table 2. Performance of adoption options with respect to sub-criteria.

Alternative	**Sub-Criteria**			
	SC_1	SC_2	SC_3	SC_n
A_1	Z_{11}	Z_{12}	Z_{13}	Z_{1n}
A_2	Z_{21}	Z_{22}	Z_{23}	Z_{12n}
A_m	Z_{m1}	Z_{m2}	Z_{m3}	Z_{mn}

The fuzzy set membership function was employed in the triangular form to obtain ideal solutions for communal decisions. A triangular fuzzy number is represented by q = (a, b, c) and the triangular membership function $\tilde{\mathrm{r}}_q$ was calculated by Equation (2). The defuzzification process, which is based on determining the maximum and minimum fuzzy numbers, was considered to diffusely transform the fuzzy set into crisp values. In addition, this process of defuzzification is more effective in arriving at crisp values compared with the centroid approach [35].

$$\tilde{\mathrm{r}}(y) = \begin{cases} 0, & if\ y < a \\ \frac{(y-a)}{(b-a)}, & if\ a \le y \le b \\ \frac{(c-y)}{(c-b)}, & if\ b \le y \le c \\ 0, & if\ y > c \end{cases} \tag{2}$$

The membership function $\tilde{\mathrm{r}}_q$ states that the weighted average is used to compute the total score. Given that U denotes a fuzzy set, the fuzzy assessment is provided as $q_{ij}^d = (a_{ij}^d,\ b_{ij}^d,\ c_{ij}^d)$, representing the decision-makers d = (1, 2 ... n) for the strength of the influence of sub-criterion i on sub-criterion j. The defuzzification process in this study applied the five-step algorithm of Chen [41] as follows:

Step 1: Normalization process

$$xa_{ij}^n = (a_{ij}^n - minc_{ij}^n)/\ \Delta_{min}^{max} \tag{3}$$

$$xb_{ij}^n = (b_{ij}^n - minc_{ij}^n)/\ \Delta_{min}^{max} \tag{4}$$

$$xc_{ij}^n = (c_{ij}^n - minc_{ij}^n)/\ \Delta_{min}^{max} \tag{5}$$

$$\text{Where } \Delta_{min}^{max} = maxa_{ij}^{n} - mina_{ij}^{n} \tag{6}$$

Step 2: Compute right (as) and left (cs) normalized values

$$xas_{ij}^{n} = xa_{ij}^{n} / \left(1 + xa_{ij}^{n} - xb_{ij}^{n}\right) \tag{7}$$

$$xcs_{ij}^{n} = xb_{ij}^{n} / \left(1 + xb_{ij}^{n} - xc_{ij}^{n}\right) \tag{8}$$

Step 3: Compute total normalized crisp values

$$x_{ij}^{n} = [xcs_{ij}^{n} \left(1 - xcs_{ij}^{n} \times xas_{ij}^{n} / [1 - xcs_{ij}^{n} - xas_{ij}^{n}\right)] \tag{9}$$

Step 4: Compute crisp values

$$u_{ij}^{n} = min_{ij}^{n} + x_{ij}^{n} \times \Delta_{min}^{max} \tag{10}$$

Step 5: Integrate crisp values

$$u_{ij} = 1/p(u_{ij}^{1} + u_{ij}^{2} + \cdots + u_{ij}^{p}) \tag{11}$$

The crisp values were used as input data for the TOPSIS, which are constructed in the next section of this research.

3.2.4. TOPSIS Method

The TOPSIS concept is based on the measurement of the alternative distance from the best and worst ideal solution. The TOPSIS is a simplified multi-criteria decision-making paradigm that has been employed widely to solve real-world problems in the existing literature, such as in Onu et al. [44]. Typically, the TOPSIS method constitutes the steps below:

Step 1: Generate a normalized matrix

The normalized decision matrix is generated by factor X_{ij} this is the normalized assessment index for the e-teaching adoption alternatives, as shown in Table 3.

Table 3. Normalized decision matrix.

Alternative	Sub-Criteria			
	SC_1	SC_2	SC_3	SC_n
A_1	X_{11}	X_{12}	X_{13}	X_{1n}
A_2	X_{21}	X_{22}	X_{23}	X_{12n}
A_m	X_{m1}	X_{m2}	X_{m3}	X_{mn}

X_{ij} is computed as:

$$X_{ij} = \frac{k_{ij}}{\sqrt{\sum_{j=1}^{n} k_{ij}^{2}}} \tag{12}$$

If, $0\langle X_{ij} \rangle 1$.

Here, the performance of each alternative in terms of each criterion is represented by X_{ij}.

Step 2: Generate the weighted normalized decision matrix

$$V_{ij} = X_{ij} \times W_j \tag{13}$$

Step 3: The ideal best $\left(H_j^{+}\right)$ and ideal worst $\left(H_j^{-}\right)$ values are calculated as:

$$H_j^{+} = \left\{H_j^{+} \ldots . H_n^{+}\right\} = \left[\left(maxh_{ij}/\ i\ \in\ I'\right),\ \left(minh_{ij}/\ i\ \in\ I''\right)\right] \tag{14}$$

$$H_j^{-} = \left\{H_j^{-} \ldots . H_n^{-}\right\} = \left[\left(minh_{ij}/\ i\ \in\ I'\right),\ \left(maxh_{ij}/\ i\ \in\ I''\right)\right] \tag{15}$$

where I' represents the beneficial criteria, and I'' represents the non-beneficial criteria.

Step 4: The separation measures (d_i^+ and d_i^-) for the alternatives are calculated by utilizing n-dimensional Euclidean distance as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - H_j^+)^2} \tag{16}$$

where $i = 1, 2 \ldots$ m; h_j (in Equation (6)) = h_j^+

$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - H_j^-)^2} \tag{17}$$

where $i = 1, 2 \ldots$ m; h_j (in Equation (6)) = h_j^-.

Step 5: The alternative (R_j) relative closeness to the ideal (R^*) solution is calculated as:

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{18}$$

$0 \leq P_i \leq 1$.

Here

I' is related to beneficial criteria, and

I'' denotes non-beneficial criteria.

Finally, the e-teaching adoption alternatives in terms of their proximity to the ideal solutions order preference.

4. Result and Discussion

4.1. Determining the E-Teaching Criteria and Sub-Criteria

The criteria and sub-criteria were constructed on the systematic literature review in Phase 1. Table 4 shows a total of four criteria and twelve sub-criteria for common variables influencing e-teaching adoption in India. Each criterion and sub-criterion were defined in terms of the frequency and heterogeneity of their occurrences. The literature review was conducted by different databases, such as Google Scholar, Scopus, and Springer. The keywords used for the review included: e-teaching issues, e-teaching adoption, e-teaching implementation, and criteria for e-teaching adoption in India. The vast literature of studies related to e-teaching adoption was identified between the time frame 2000–2022 in both phases. During this time, 48 academic articles and 13 government reports in phase 1 and 27 review papers and 8 books in phase 2 were identified. In total, 64 academic articles from different journals related to e-teaching were shortlisted. There were several published studies that identified the potential criteria in the education system. For example, Wong et al. [49] determined limited time for virtual learning preparation as a drawback, making a teacher's subject or course unsuitable for e-teaching [8]. Accordingly, Maatuk et al. [9] noted a lack of training network issues, less attendance, lack of basic facilities, lack of internet (or) slow connectivity, and security concern as critical challenges confronting teachers to adapt to e-teaching.

Table 4. List of criteria and sub-criteria for the e-teaching adoption.

Criteria	Sub-Criteria	Definition	References
Technological factors (C1)	Lack of basic facilities (*SC1*)	The teacher's need for adequate technological infrastructure (hardware, software, and the internet) in order to conduct classes using the e-teaching method.	Saha et al. [16]; Joshi et al. [50]; Ferri et al. [51]
	Lack of internet (or) slow connectivity (*SC2*)	Most schools are unable to connect to the Internet due to the high price of access.	Maatuk et al. [8]; Cutri et al. [11]; Dwivedi et al. [52];
	Security concern (*SC3*)	Teachers who use open-source software for online classes are cautious about security concerns. They are not comfortable with teaching.	Naylor and Nyanjom [5]; Uiboleht et al. [32]; Dwivedi et al. [52]

Table 4. *Cont.*

Criteria	Sub-Criteria	Definition	References
Institutional factors (C2)	Institutional strategy and support (*SC4*)	Access to quality resources, technical support, and the presence of quality infrastructure from institutions.	Naylor and Nyanjom [5]; Ekinci et al. [15]; Oyedotun [26]
	The e-teaching system and culture (*SC5*)	The e-teaching culture is founded on knowledge sharing and collaborative learning, hence the employed system must be efficient and of high quality.	Cutri et al. [11]; Ekinci et al. [15]; Rhongo and Piedade [53]
	Budget for technologies (*SC6*)	Many schools currently lack advanced technology; nevertheless, institutions have the financial resources to invest in e-teaching development.	Maatuk et al. [8]; Sundqvist et al. [12]; Saha et al. [18]
Teachers readiness factors (C3)	Teacher skills for e-teaching (*SC7*)	Teachers' inadequate technical computer abilities and lack of faith in individuals who work with the platform.	Naylor and Nyanjom, [5]; Rhongo and Piedade [50]; Wong et al. [49]
	Pedagogical support (*SC8*)	Teacher training is inadequate, especially regarding learning how to teach online; not only in the technology context.	Saha et al. [16]; Ferri et al. [51]; Butler-Henderson and Crawford [54]
	Psychological factors (*SC9*)	The teacher's stress, mental conditions while using the technical tools and the time required to prepare courses using the technological platforms.	Cutri et al. [11]; Ekinci et al. [15]; Butler-Henderson and Crawford [54]
Environmental factors (C4)	Government policy (*SC10*)	The lack of legal framework for the education system in India. E-teaching implementation will not be applied by institutions without a legal framework.	Sundqvist et al. [12]; Saha et al. [16]; Uiboleht et al. [32]
	Lack of culture of sharing (*SC11*)	The important material used online is very often a problem for teachers. Therefore, information sharing is effective involvement of teachers.	Naylor and Nyanjom [5]; Ekinci et al. [16]; Oyedotun [26]
	The social norm (*SC12*)	The social norm arises in the teacher's own beliefs and values, influencing colleagues to adopt e-teaching.	Sundqvist et al. [12]; Saha et al. [16]; Scull et al. [55]

4.2. Fuzzy Delphi Method Result

A summary of the 12 sub-criteria is shown in Table 4. FDM was further applied to obtain important sub-criteria before Fuzzy TOPSIS was performed. Then, respondents' inputs from the questionnaires were taken into consideration. The participants were asked to score on a scale of five points, i.e., strongly agree, fairly agree, disagree, and strongly disagree for 1, 2, 3, 4, and 5, respectively. The responders were from public and private EOs, as shown in Table 1. All of the responders had more than five years of experience in their current organization. The responder's input was converted into fuzzy numbers, and the fuzzy values were then converted into de-fuzzification values according to the FDM steps mentioned in Section 3.2.1. Based on the respondents' assessment, twelve sub-criteria were finalized based on the threshold value (0.70) of the FDM analysis, as shown in Table 5.

Table 5. Fuzzy Delphi method results at the threshold value (0.70).

Sub-Criteria	Defuzzification Value	Threshold Value (0.70)
SC1	0.713	Accept
SC2	0.767	Accept
SC3	0.791	Accept
SC4	0.729	Accept
SC5	0.714	Accept
SC6	0.756	Accept
SC7	0.733	Accept
SC8	0.717	Accept
SC9	0.788	Accept
SC10	0.765	Accept
SC11	0.740	Accept
SC12	0.703	Accept

4.3. Fuzzy Result

After the sub-criteria and alternatives were finalized based on an FDM finding of 0.70, fuzzy logic was applied to convert the linguistic terms into crisp values and then analyzed by MATLAB. Table A1 illustrates the fuzzy numbers from each responder. The triangular fuzzy numbers of respondents were standardized into crisp values via the defuzzification process using Equations (2)–(6), as shown in Table A2. In addition, the right and left-side values were determined using Equations (7) and (8), as shown in Table A3. The normalized crisp values of responders were calculated by Equation (9). In addition, Equation (10) was used to calculate the total normalized crisp values. Then, the crisp values are assimilated by utilizing Equation (11). The same procedure was used to find the total normalized crisp values of sub-criteria. Finally, Table 6 illustrates the normalized crisp values of fuzzy numbers of responders in India for the sub-criteria affecting e-teaching adoption.

Table 6. Normalized crisp values of fuzzy numbers of responders.

	A1	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
SC1	0.361	0.338	0.273	0.241	0.169	0.313	0.407	0.238
SC2	0.374	0.375	0.265	0.41	0.375	0.238	0.327	0.195
SC3	0.362	0.277	0.223	0.255	0.231	0.212	0.335	0.182
SC4	0.295	0.275	0.233	0.235	0.198	0.205	0.146	0.218
SC5	0.248	0.182	0.348	0.392	0.305	0.363	0.378	0.348
SC6	0.344	0.433	0.39	0.237	0.275	0.316	0.265	0.278
SC7	0.346	0.354	0.305	0.388	0.266	0.211	0.219	0.179
SC8	0.326	0.153	0.248	0.242	0.391	0.156	0.12	0.280
SC9	0.168	0.223	0.284	0.357	0.346	0.272	0.335	0.195
SC10	0.195	0.259	0.455	0.199	0.177	0.363	0.374	0.258
SC11	0.452	0.208	0.415	0.307	0.313	0.295	0.276	0.172
SC12	0.345	0.370	0.300	0.220	0.308	0.350	0.171	0.201

4.4. TOPSIS Method Result

After obtaining the normalized crisp values matrix, the TOPSIS method was applied to allocate the rank to each alternative for e-teaching adoption. The TOPSIS model used the fuzzy logic normalized crisp values as the input. Equation (12) was used to generate the normalized matrix, as shown in Table 7. Additionally, Equation (13) was used in order to compute the weighted normalized decision matrix.

Table 7. Normalized matrix.

	A1	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
SC1	0.319	0.326	0.247	0.232	0.169	0.320	0.399	0.293
SC2	0.330	0.362	0.239	0.395	0.375	0.243	0.321	0.240
SC3	0.320	0.267	0.201	0.246	0.231	0.217	0.329	0.224
SC4	0.260	0.265	0.210	0.227	0.198	0.210	0.143	0.269
SC5	0.219	0.176	0.314	0.378	0.305	0.371	0.371	0.429
SC6	0.304	0.418	0.352	0.229	0.275	0.323	0.260	0.343
SC7	0.305	0.342	0.275	0.374	0.266	0.216	0.215	0.221
SC8	0.288	0.148	0.224	0.233	0.391	0.159	0.118	0.345
SC9	0.148	0.215	0.256	0.344	0.346	0.278	0.329	0.240
SC10	0.172	0.250	0.411	0.192	0.177	0.371	0.367	0.318
SC11	0.399	0.201	0.375	0.296	0.313	0.302	0.271	0.212
SC12	0.305	0.357	0.271	0.212	0.308	0.358	0.168	0.248

The weighted normalized matrix of sub-criteria for e-teaching adoption is shown in Table 8. Equations (14) and (15) were also used to compute the positive and negative ideal solutions.

Table 8. Weighted normalized matrix.

	A1	***A2***	***A3***	***A4***	***A5***	***A6***	***A7***	***A8***
SC1	0.040	0.041	0.031	0.029	0.021	0.040	0.050	0.037
SC2	0.041	0.045	0.030	0.049	0.047	0.030	0.040	0.030
SC3	0.040	0.033	0.025	0.031	0.029	0.027	0.041	0.028
SC4	0.033	0.033	0.026	0.028	0.025	0.026	0.018	0.034
SC5	0.027	0.022	0.039	0.047	0.038	0.046	0.046	0.054
SC6	0.038	0.052	0.044	0.029	0.034	0.040	0.032	0.043
SC7	0.038	0.043	0.034	0.047	0.033	0.027	0.027	0.028
SC8	0.036	0.018	0.028	0.029	0.049	0.020	0.015	0.043
SC9	0.019	0.027	0.032	0.043	0.043	0.035	0.041	0.030
SC10	0.022	0.031	0.051	0.024	0.022	0.046	0.046	0.040
SC11	0.050	0.025	0.047	0.037	0.039	0.038	0.034	0.026
SC12	0.038	0.045	0.034	0.027	0.039	0.045	0.021	0.031

The positive and negative separation measures (S_i^+ and S_i^-) were determined by Equations (16) and (17) for the alternatives using the n-dimensional Euclidean distance. Finally, Equation (18) was used to compute the relative closeness to the ideal solution P_i (TOPSIS index), which is the total performance of the criteria and alternatives. The calculations of separation measures, as well as relative closeness to the ideal solutions, are noted in Table 9.

Table 9. Ranking of alternatives to e-teaching adoption.

Alternatives	S_i^+	S_i^-	$S_i^+ + S_i^-$	P_i	**Rank**
A1 (Recruitment the skilled teachers)	0.063	0.031	0.094	0.333	8
A2 (Course integration with technology)	0.042	0.055	0.097	0.565	2
A3 (Use outsourcing for technology)	0.055	0.039	0.094	0.417	6
A4 (Effective utilization of resources)	0.048	0.049	0.097	0.504	5
A5 (Use the free e-teaching platforms)	0.061	0.040	0.100	0.394	7
A6 (Find the low-cost technology)	0.046	0.048	0.093	0.512	4
A7 (Share the technology with other organizations)	0.035	0.055	0.090	0.614	1
A8 (Conducting in-person classes on alternating days)	0.052	0.055	0.107	0.516	3

The ranking of alternatives to e-teaching adoption are noted in Table 9. The alternative for sharing technology with other organizations (*A7*) occupies the first position, with an index value of 0.614, whereas recruitment of skilled teachers (*A1*) was at the last place in the ranking, with an index value of 0.333. The second-best alternative is course integration with technology (*A2*), with an index value of 0.565, while the third-best alternative is conducting in-person classes on alternating days (*A8*), with an index value of 0.516. It was found that sharing the technology with other organizations (*A7*) is the best alternative for e-teaching adoption, with the highest performance in terms of relevant sub-criteria. Therefore, this study suggests that EOs should focus on technology sharing with different organizations based on the preferred tasks for better e-teaching with limited resources and less investment in technology.

Compared with the available literature, the results of this study both share similarities and show distinctions. For similarities, the alternative of sharing the technology with other organizations (*A7*) was the best, which is paralleled with [32] and the recruitment of skilled teachers (*A1*) was the least, which is aligned with [8,53]. In addition, free e-teaching platforms (*A5*) and recruitment of skilled teachers (*A1*) affected e-teaching the least, which is supported by study [8]. For differences, conducting in-person classes on alternating days (*A8*) ranked in the third position, while in [45], it was in first place. Furthermore, Dwivedi et al. [52] indicated that the recruitment of skilled teachers (*A1*) and the effective utilization of resource (*A4*) alternatives are less essential. Oyedotun [26] decided that the effective utilization of resources (*A4*), finding low-cost technology (*A6*), and sharing the technology with other organizations (*A7*) were the most important factors, whereas course integration with technology (*A2*) and conducting in-person classes on alternating days (*A8*) were the least important. In other studies, Maatuk et al. [8] discovered that the alternative use of outsourcing for technology (*A3*) is the best option for e-teaching in developed countries.

5. Conclusions

The growth of the global knowledge economy and Information and Communication Technology (ICT) shows an increasing tendency toward online education and e-teaching adoption in EOs. Despite its status as a developing country, India has quickly caught up to this trend and is now a potential investment opportunity for both domestic and international investors. In order to achieve better e-teaching performance and maintain students' academic performance in online classes, it is vital for EOs, policymakers, and researchers to identify criteria and alternatives for e-teaching adoption. Concerning the issues of implementing e-teaching, it is necessary to address the uncertainty of the assessment environment that exists during the decision-making process. In addition, the present research has provided an appropriate solution for e-teaching adoption. This study's outcome determined that "sharing the technology with other organizations", and "course integration with technology" were the most important alternatives for e-teaching adoption in India. Successful e-teaching adoption requires not only technology sharing, innovative thinking, and positive changes in teachers' and students' behaviors, but also the important criteria and alternatives. This study result could be useful to researchers and organizations in assisting the adoption of e-teaching for EOs in India.

The current research proposed an integrated Fuzzy Delphi-TOPSIS method to determine criteria and rank the alternatives for e-teaching adoption in India for the first time. To the best of our knowledge, the proposed integrated methodology is not described in the literature on education systems. However, this study identified a comprehensive list of sub-criteria that was defined based on a systematic review of the literature and responders' input. In addition, the integrated fuzzy methodology was proposed to rank the alternatives. This assessment would be useful for EOs and governments to understand the importance of e-teaching. In particular, the priority or importance of the sub-criteria could be identified from this study's Fuzzy Delphi method results. In addition, the authors have employed TOPSIS analysis with fuzzy theory to rank the alternatives for e-teaching adoption. The identified sub-criteria list would be a useful reference for EOs and governments, since they could incorporate the best alternatives in their short- and long-term strategies for better e-teaching adoptions. However, the proposed fuzzy integrated methodology seems to have the advantage of processing the uncertain assessments exhibited by fuzzy numbers in order to produce a more accurate and efficient ranking for the alternatives. This study presented a realistic assessment of e-teaching adoption in India for the first time. A combination of fuzzy applications is performed to analyze the e-teaching adoption model. This research outcome could offer first-hand knowledge for EO's to adopt e-teaching to allow them to overcome the present global pandemic era.

Finally, this study had a number of limitations. First, this research mainly focused on e-teaching adoption for EOs in India. However, e-teaching adoption problems vary greatly among various countries, whether they are developed or developing countries. Second, the results of this study have not been statistically verified, as it was conducted within constraints, such as limited resources and a limited number of respondents; thus, the ranked alternatives were based on the subjective judgment of selected respondents from EOs in India. However, this study was considered a pilot phase of the Fuzzy Delphi-TOPSIS method for alternative selection and sub-criteria ranking for e-teaching adoption. Therefore, the following research directions are recommended for future researchers. First, the developed method is confined to a smaller number of respondents who are from only India. In the future, it is recommended that future studies should be based on larger groups of respondents from more regions. Second, future researchers could conduct a comprehensive model study by incorporating other evaluation criteria and alternatives to overcome the current issues faced by EOs, such as utilizing cutting-edge technologies and the COVID-19 pandemic. Furthermore, it is recommended that sophisticated MCDM methods such as VIKOR, DEA, and others are advocated to evaluate the criteria of e-teaching adoption. Finally, this study recommends using the spherical fuzzy set theory to provide paths for scholars to acquire more effective results.

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Appendix A

Table A1. Fuzzy numbers of responders.

	A1	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
SC1	(0,0,0.25)	(0,0.25,0.50)	(0.50,0.75,1.00)	(0.25,0.50,0.75)	(0,0.25,0.50)	(0.50,0.75,1.00)	(0.75,1.00,1.00)	(0,0,0.25)
SC2	(0.50,0.75,1.00)	(0.75,1.00,1.00)	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0.50,0.75,1.00)	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0,0.25,0.50)
SC3	(0.25,0.50,0.75)	(0,0,0.25)	(0.75,1.00,1.00)	(0,0.25,0.50)	(0.75,1.00,1.00)	(0.50,0.75,1.00)	(0,0.25,0.50)	(0.25,0.50,0.75)
SC4	(0,0,0.25)	(0.25,0.50,0.75)	(0,0,0.25)	(0,0.25,0.50)	(0,0,0.25)	(0,0,0.25)	(0,0,0.25)	(0,0.25,0.50)
SC5	(0,0.25,0.50)	(0.75,1.00,1.00)	(0.50,0.75,1.00)	(0.25,0.50,0.75)	(0.75,1.00,1.00)	(0,0,0.25)	(0,0.25,0.50)	(0.50,0.75,1.00)
SC6	(0.75,1.00,1.00)	(0.75,1.00,1.00)	(0.50,0.75,1.00)	(0,0,0.25)	(0.75,1.00,1.00)	(0.50,0.75,1.00)	(0.25,0.50,0.75)	(0,0.25,0.50)
SC7	(0.75,1.00,1.00)	(0,0.25,0.50)	(0,0,0.25)	(0.50,0.75,1.00)	(0,0.25,0.50)	(0,0.25,0.50)	(0,0,0.25)	(0.75,1.00,1.00)
SC8	(0.50,0.75,1.00)	(0,0.25,0.50)	(0,0.25,0.50)	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0,0.25,0.50)	(0.75,1.00,1.00)	(0,0,0.25)
SC9	(0,0,0.25)	(0,0.25,0.50)	(0.50,0.75,1.00)	(0.75,1.00,1.00)	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0.75,1.00,1.00)	(0,0.25,0.50)
SC10	(0,0.25,0.50)	(0.50,0.75,1.00)	(0,0,0.25)	(0.25,0.50,0.75)	(0,0.25,0.50)	(0.75,1.00,1.00)	(0.50,0.75,1.00)	(0,0.25,0.50)
SC11	(0.75,1.00,1.00)	(0,0,0.25)	(0.25,0.50,0.75)	(0,0,0.25)	(0.75,1.00,1.00)	(0.25,0.50,0.75)	(0.25,0.50,0.75)	(0.25,0.50,0.75)
SC12	(0.25,0.50,0.75)	(0.75,1.00,1.00)	(0,0.25,0.50)	(0,0,0.25)	(0,0.25,0.50)	(0,0,0.25)	(0,0.25,0.50)	(0.50,0.75,1.00)

Table A2. Normalized triangular fuzzy numbers of responder.

	A1	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
SC1	(0,0,0)	(0,0.25,0.25)	(0.50,0.75,0.75)	(0.25,0.50,0.50)	(0,0.25,0.25)	(0.50,0.75,0.75)	(0.75,1,0.75)	(0,0,0)
SC2	(0.50,0.75,0.75)	(0.75,1,0.75)	(0.25,0.50,0.50)	(0.50,0.75,0.75)	(0.50,0.75,0.75)	(0.25,0.50,0.50)	(0.50,0.75,0.75)	(0,0.25,0.25)
SC3	(0.25,0.5,0.5)	(0,0,0)	(0.75,1,0.75)	(0,0.25,0.25)	(0.75,1,0.75)	(0.50,0.75,0.75)	(0,0.25,0.25)	(0.25,0.50,0.50)
SC4	(0,0,0)	0.25,0.50,0.50)	(0,0,0)	(0,0.25,0.25)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0.25,0.25)
SC5	(0,0.25,0.25)	(0.75,1,0.75)	(0.50,0.75,0.75)	(0.25,0.50,0.50)	(0.75,1,0.75)	(0,0,0)	(0,0.25,0.25)	(0.50,0.75,0.75)
SC6	(0.75,1,0.75)	(0.75,1,0.75)	(0.50,0.75,0.75)	(0,0,0)	(0.75,1,0.75)	(0.50,0.75,0.75)	(0.25,0.50,0.50)	0,0.25,0.25)
SC7	(0.75,1,0.75)	(0,0.25,0.25)	(0,0,0)	(0.5,0.75,0.75)	(0,0.25,0.25)	(0,0.25,0.25)	(0,0,0)	(0.75,1,0.75)
SC8	(0.50,0.75,0.75)	(0,0.25,0.25)	(0,0.25,0.25)	(0.25,0.50,0.50)	(0.50,0.75,0.75)	(0,0.25,0.25)	(0.75,1,0.75)	(0,0,0)
SC9	(0,0,0)	(0,0.25,0.25)	(0.50,0.75,0.75)	(0.75,1,0.75)	(0.25,0.50,0.50)	(0.50,0.75,0.75)	(0.75,1,0.75)	(0,0.25,0.25)
SC10	(0,0.25,0.25)	0.5,0.75,0.75)	(0,0,0)	(0.25,0.50,0.50)	(0,0.25,0.25)	(0.75,1,0.75)	(0.50,0.75,0.75)	(0,0.25,0.25)
SC11	(0.75,1,0.75)	(0,0,0)	(0.25,0.50,0.50)	(0,0,0)	(0.75,1,0.75)	(0.25,0.50,0.50)	(0.25,0.50,0.50)	(0.25,0.50,0.50)
SC12	(0.25,0.5,0.5)	(0.75,1,0.75)	(0,0.25,0.25)	(0,0,0)	(0,0.25,0.25)	(0,0,0)	(0,0.25,0.25)	(0.50,0.75,0.75)

Table A3. Calculate left and right normalized values of a responder.

	A1	A2	A3	A4	A5	A6	A7	A8
SC1	(0.00,0.00)	(0.00,0.25)	(0.67,0.75)	(0.33,0.50)	(0.00,0.25)	(0.67,0.75)	(1.00,0.80)	(0.00,0.00)
SC2	(0.67,0.75)	(1.00,0.80)	(0.33,0.50)	(0.67,0.75)	(0.67,0.75)	(0.33,0.50)	(0.67,0.75)	(0.00,0.25)
SC3	(0.33,0.50)	(0.00,0.00)	(1.00,0.80)	(0.00,0.25)	(1.00,0.80)	(0.67,0.75)	(0.00,0.25)	(0.33,0.50)
SC4	(0.00,0.00)	(0.33,0.50)	(0.00,0.00)	(0.00,0.25)	(0.00,0.00)	(0.00,0.00)	(0.00,0.00)	(0.00,0.25)
SC5	(0,0.25)	(1.00,0.80)	(0.67,0.75)	(0.33,0.50)	(1.00,0.80)	(0.00,0.00)	(0.00,0.25)	(0.67,0.75)
SC6	(1.00,0.80)	(1.00,0.80)	(0.67,0.75)	(0.00,0.00)	(1.00,0.80)	(0.67,0.75)	(0.33,0.50)	(0.00,0.25)
SC7	(1.00,0.80)	(0.00,0.25)	(0.00,0.00)	(0.67,0.75)	(0.00,0.25)	(0.00,0.25)	(0.00,0.00)	(1.00,0.80)
SC8	(0.67,0.75)	(0.00,0.25)	(0.00,0.25)	(0.33,0.50)	(0.67,0.75)	(0.00,0.25)	(1.00,0.80)	(0.00,0.00)
SC9	(0.00,0.00)	(0.00,0.25)	(0.67,0.75)	(1.00,0.80)	(0.33,0.50)	(0.67,0.75)	(1.00,0.80)	(0.00,0.25)
SC10	(0.00,0.25)	(0.67,0.75)	(0.00,0.00)	(0.33,0.50)	(0.00,0.25)	(1.00,0.80)	(0.67,0.75)	(0.00,0.25)
SC11	(1.00,0.80)	(0.00,0.00)	(0.33,0.50)	(0.00,0.00)	(1.00,0.80)	(0.33,0.50)	(0.33,0.50)	(0.33,0.50)
SC12	(0.33,0.50)	(1.00,0.80)	(0.00,0.25)	(0.00,0.00)	(0.00,0.25)	(0.00,0.00)	(0.00,0.25)	(0.67,0.75)

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