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Multi-expert and multi-criteria evaluation of Online Education Factors: A fuzzy AHP approach

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Abstract : COVID-19 has highly impacted industry, agriculture, services sector as well as education sector all over the world. The countries have seen a complete lockdown, and it has badly affected students' lives in the education sector. Almost more than 32 crores of learners are unable to move to schools or colleges in India. The solution to overcome the offline education crisis is to move to online platforms. But, the effectiveness of online platforms for teaching is a big challenge. The most important thing in teaching is achieving the satisfaction level of students. The literature shows many factors impact satisfaction level, and these factors are ICT orientation, Big-Five Personality Dimensions, Instructor Quality, and Course Design. These factors are having subfactors four, five, seven, and six, respectively. The current study targets to prioritize the factors by using the fuzzy AHP approach. The factors are pritorized based on their normalized weight. To gain depth insights, the sub-factors are also prioritized, and they are ranked relatively as well as globally. Relatively means to figure out the important and least sub-factor from the corresponding factor, globally means to rank each sub-factor among all identified factors. The results show that BF is the most important and CD is the least important factor for achieving students satisfaction level. Looking at relative weights, NE and LQ are the most important factors among BF and CD, respectively. After considering global weights, PI and AD are the most and least important sub-factors, respectively.

Keywords: Online Classes, Fuzzy AHP, Instructor Quality, ICT Orientation, COVID 19

1. Introduction

A matchless and distinctive pandemic has spread at the end of 2019 in China and has killed many thousands of Chinese in few weeks of its spread (He, Deng, & Li, 2020). This virus is named severe acute respiratory syndrome coronavirus 2 by the World Health Organization and the disease is named "COVID-19" or, in other words, coronavirus disease 2019. This disease has impacted China and the whole planet affected by this disease in a very short period (Shereen, Khan, Kazmi, Bashir, & Siddique, 2020). This resulted in the declaration of national emergency in most of the countries. This pandemic has forced the globe to alter its working conditions. Almost more than 120 nations have moved their educational system to online platforms rather than classical face-to-face communication in classrooms (Basilaia & Kvavadze, 2020), (Azzi-Huck and Shmis, 2020; Shahzad et al., 2020), (Bao, 2020). The Indian government also took different steps to cope with the large-scale spreading of COVID-19. They have initially shut down schools and universities, social distancing measures, and cities' lockdown (Zhang, Wang, Yang, & Wang,

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2020). Slowly and steadily, countries have coped up with this virus by inventing injections and medicine dosage, but the virus is coming in new forms again and again. Many countries are again declaring lockdown in many areas to stop the spread of COVID 19. This whole scenario has promoted online learning instead of classroom teaching, and different innovations have been developed to make learning interactive on online platforms (Di Vaio, Boccia, Landriani, & Palladino, 2020), (Roff, 2018; Chopra et al., 2019). According to reports, 1.8 billion learners are affected, and 40% of the poorest countries failed to support learners during the COVID crisis (UNESCO, 2020). The Indian government is spending a lot of money on higher educational institutes to promote Massive Open Online Courses (MOOCs) and expects around 16.4% of growth annually for online learners until 2023 (Shahzad et al., 2020). Not only India, other countries are also promoting online education. Some movements like "Suspending classes without Stopping Learning" are initiated too. But while moving to online platform, there are certain challenges for academicians and students. One of the challenges is to engross students and regale them in the teaching-learning process, not only content matters but also students' engagement is a need of the hour. Quality content delivery is a desirable factor during online teaching. During the e-learning process, issues like inappropriate audio voice, resolution issues, downloading and uploading content, internet speed, etc. exist that make e-learning tougher and harder. This study focuses on prioritizing the factors that impact online teaching. The rest of the paper is organized as follows: Section 2 reports the previous literature on what factors impact online educational systems and different authors' perspectives. Section 3 describes the research methodology that has been used in the current study, followed by Section 4 that shows the implementation of fuzzy AHP on the experts' opinions. The last section 5, discusses the empirical findings in detail and conclusion.

2. Literature Review

The success of the educational online system only depends upon its key users who are using it (Almaiah & Al Mulhem, 2018), (Tartavulea, Albu, Albu, Dieaconescu, & Petre, 2020). Mainly, there are two key players: students,' and the other one is teachers'. The authors (Teo, 2011; Warren, Rixner, Greiner, & Wong, 2014) have tried to investigate the factors that explain teachers' intention to use the latest technology. Some authors tried to figure out the factors of students' acceptance towards the online system and learners are actively involved in the learning process (Almaiah, Jalil, & Man, 2016a), (Almaiah, Jalil, & Man, 2016b), (Englund, Olofsson, & Price, 2017), (Garba Shawai & Amin Almaiah, 2018), (Amin Almaiah, Al-Khasawneh, & Althunibat, 2020). Online education supports both types of synchronous and asynchronous communication (Kearns, 2012). Synchronous communication means both teacher and student are online simultaneously and share text messages, applications and having audio, video conferences (Huang, 2020), whereas asynchronous communication allows messages transmission at any time and can be viewed later and responded later. This communication mechanism includes blogs, chats, emails, tutorials, virtual boards, etc. (Craig, Coldwell-Neilson, Goold, & Beekhuyzen, 2012). The most important factor is instrument methods that are used for the online educational system (Bangert, 2006), (Dixson, 2010). Along with interaction methods, the vital point is to encourage interaction and exchange of ideas between students and teachers (Gaytan & McEwen, 2007), (Dixson, 2010), (Almaiah & Al Mulhem, 2018) such that learning process results are beneficial (Bennett, Lockyer, & Agostinho, 2018). To make online education effective, many authors have put efforts and compared online systems with offline systems (Connolly, MacArthur, Stansfield, & McLellan, 2007), (Englund et al., 2017).

There are numerous challenges associated with the online educational system, and many authors have mentioned these challenges in their researches like poor infrastructure (Makokha & Mutisya, 2015), (Aung & Khaing, 2016), (Mulhanga & Lima, 2017), (Kanwal & Rehman, 2017), (Bao, 2020) lack of content quality (Makokha & Mutisya, 2015), (Aung & Khaing, 2016), ICT knowledge (Pelgrum, 2001), (Makokha & Mutisya, 2015), (Aung & Khaing, 2016), (Mulhanga & Lima, 2017), (Kanwal & Rehman, 2017), (Al-araibi, Mahrin, & Yusoff, 2019).

While teaching online, the satisfaction level of the students is a fundamental key attribute. Numerous factors impact students satisfaction level, and these are Instructor Quality (Ramsden, 1991), (Maina, 2010), (Munteanu, Ceobanu, Bobâlcă, & Anton, 2010), (Kukreja, Sakshi, Kaur, & Aggarwal, 2021), Course Design (Wooldridge & Jennings, 1995), (paul Black, 2004), (Liaw, 2008), (Lin, Lin, & Laffey, 2008), (Kukreja et al., 2021) Technology (Kalafatis,

Pollard, East, & Tsogas, 1999), (Shinn, Poston, Kimball, St. Jeor, & Foreyt, 2001), (Manochehri & Young, 2006), (Endres, Chowdhury, Frye, & Hurtubis, 2009), (Biasutti & El-Deghaidy, 2012), (Ajzen, 2015), (Gray & DiLoreto, 2016), (Mitić, Nikolić, Jankov, Vukonjanski, & Terek, 2017), (Kukreja et al., 2021), Students traits (Eysenck, 1992), (Mccrae & Costa, 1999), (Hofstee, de Raad, & Goldberg, 1992), (Bidjerano & Dai, 2007), (Keller & Karau, 2013), (Cohen & Baruth, 2017).

3. Research Methodology

A. Background

The current study is the extension of the paper "What factors impact online education? A factor analysis approach" published by authors (Kukreja et al., 2021). The authors have figured out the factors and sub-factors that impact students' satisfaction levels as mentioned in Annexure A. However, the limitation of this paper was that this paper doesn't prioritized the factors that affect the students' satisfaction levels. Therefore, the current study has used a fuzzy analytical hierarchical process (FAHP) to rank the factors and sub-factors that impact the customers' satisfaction level. Here, a nine-point Likert scale is used to rate the factors.

B. Measure

This study is quantitative in nature, and a survey has been conducted with 15 experts to rate the factors on a scale of 1 to 9. The survey consists of two sections, the first section consists of experts' profiles. In contrast, the second section consists of independent factors, namely course design, instructor quality, student traits ("extraversion, agreeableness, conscientiousness, negative emotionality and open-mindedness"), and ICT orientation ("ease of use; advantage, compatibility, and perception"). The nine-point Likert scale is used for measuring these variables, where one stands for "equal" to nine stands for "tremendous". The survey was conducted to prioritize the factors and sub-factors to know that which highly impacts factor/sub-factor towards student's satisfaction level. The Big-2-S version of Soto and John's big-five personality dimension (Soto & John, 2017) is used in the present study. The student's traits include dimensions like Open-Mindedness, Negative Emotionality, Agreeableness, Extraversion, and Conscientiousness. The ICT orientation has dimensions like Advantage, Ease of Use, Compatibility, and Perception, and scale used by the authors Bhat and Basshir (2018). Instructor quality includes seven dimensions, and Course design consists of six dimensions.

C. Prioritization Method: FAHP

Many multi-criteria decision-making techniques are used to rank the criteria and sub-criteria, and one of the most powerful and dominant techniques is the fuzzy analytical hierarchical process (FAHP). This technique is based on the fuzzy set theory, and (Chang 1996) has used fuzzy triangular numbers for making pairwise comparisons among criteria and sub-criteria. This is used to rank the identified criteria and sub-criteria based on their weights calculated. The method that has been used in the FAHP is discussed as:

Step 1: Equation 1 that is mentioned below is used to form pairwise matric for all criteria and sub-criteria with the help of experts' opinions by using the linguistic scale as mentioned in Table 3.

$$\tilde{Z} = \begin{bmatrix} 1,1,1 & \tilde{z}_{12} & \tilde{z}_{13} & \tilde{z}_{14} & \cdots & \tilde{z}_{1n} \\ \tilde{z}_{21} & 1,1,1 & \tilde{z}_{23} & \tilde{z}_{24} & \cdots & \tilde{z}_{2n} \\ \tilde{z}_{31} & \tilde{z}_{32} & 1,1,1 & \tilde{z}_{34} & \cdots & \tilde{z}_{3n} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{z}_{n1} & \tilde{z}_{n2} & \tilde{z}_{n3} & \tilde{z}_{n4} & \cdots & 1,1,1 \end{bmatrix}$$

where $\tilde{z}$ = (lab,mab,uab) and a ,b= 1,2,3,4,5……n are triangular fuzzy numbers.

$$FC_a = \left(\sum_{b=1}^{n} l_b \, , \sum_{b=1}^{n} m_b \, , \sum_{b=1}^{n} \mu_b\right) * \left(\frac{1}{\sum_{a=1}^{n} \mu_a} , \frac{1}{\sum_{a=1}^{n} m_a} , \frac{1}{\sum_{a=1}^{n} l_a}\right) \quad (2)$$

Step 2: With the help of equation 2, the fuzzy synthetic extent value (FV) is calculated for the fuzzy synthetic criteria (FC). Here, triangular fuzzy numbers (TFN) have been used.

Step 3: Use equation 3, equation 4 and equation 5 to figure out the degree of possibility (D) as:

$$DV(D1 >= D2) = 1 \text{ iff } m1 >= m2 \quad (3)$$

$$DV(D1 >= D2) = 0 \text{ iff } l1 >= u2 \quad (4)$$

$$DV(D_2 \geq D_1) = \frac{l_1 - \mu_2}{(m_2 - \mu_2) - (m_1 - l_1)} \quad (5)$$

Equation 6, Equation 7 helps in the calculation of the fuzzy weight (FuzzyW), non-fuzzy weight/normalized weight, respectively:

FuzzyW` = (d`(Z1), d`(Z2), d`(Z3), d`(Z4)……. d`(Zn))T where d`(Zi) = min DV(FCa >= FCb) and a,b =1,2,3…n and a≠b (6)

FuzzyW=(d(C1),d(Z2),d(Z3),d(Z4).....d(Zn))T (7)

4. FAHP implementation

To start the process, criteria and sub-criteria are abbreviated as shown in table 1 and table 2. The pairwise scale for linguistic terms is shown in table 3. Table 4 shows the TFN for all the criteria that have been used in the current study.

Table 1: Criteria with Abbreviations

Criteria	Abbreviations
ICT orientation	IO
Big-Five Personality Dimensions	BF
Instructor Quality	IQ
Course Design	CD

Table 2: Sub-criteria with Abbreviations

Sub-criteria	Abbreviations	Sub-criteria	Abbreviations
Advantage	AD	Extraversion	EN
Compatibility	CY	Agreeableness	AS
Ease of Use	EU	Conscientiousness	CS
Perception	PN	Negative Emotionality	NE
Communication	CN	Open-Mindedness	OM
Enthusiastic	ES	Well organized	WO
Concerned about student learning	CL	Supports d ifferent learning environments	SE
Respectful of student learning	RL	Facilitated the course effectively	FE
Accessible	AE	Webinar usage	WU
Comfortable learning space	CLS	Learn educational statistics quickly	LQ
Personalized interactions	PI	Take responsibility for learning	TL

Table 3: Fuzzy Linguistic Assessment Variables

Linguistic Term	TFNs (l,m,u)	Linguistic Term	TFNs (l,m,u)	Linguistic Term	TFNs (l,m,u)
Equal	1 = (1,1,1)	Moderate	3 = (2,3,4)	Intermediate value between Equal and Moderate	2 = (1,2,3)
Strong	5 = (4,5,6)	Very Strong	7 = (6,7,8)	Intermediate value between Strong and Very Strong	6 = (5,6,7)
Tremendous	9 = (9,9,9)	Intermediate value between Moderate and Strong	4 = (3,4,5)	Intermediate value between Very Strong and Tremendous	8 = (7,8,9)

This Table 4 has been made after taking the opinions of 15 experts and further their the average of experts is taken for the calculation.

Table 4: TFN decision matrix of the criteria

Criteria	IO	BF	IQ	CD
IO	(1,1,1)	(2.00,3.00, 4.00)	(0.24,0.33,0.56)	(1.42,2.11 ,2.83)
BF	(0.25,0.33,0 .50)	(1,1,1)	(4.00,5.00,6.00)	(2.39,3.07 ,3.75)
IQ	(2.33,3.33,4 .33)	(0.18,0.22, 0.30)	(1,1,1)	(3.00,4.00 ,5.00)
CD	(0.83,1.22,1 .67)	(1.46,1.83, 2.23)	(0.21,0.28,0.40)	(1,1,1)

After calculation of the decision matrix, the fuzzy synthetic extent value for criteria is calculated, and this is shown in table 5.

Table 5: Fuzzy Synthetic extent value of criteria

Fuzzy Synthetic Criteria	Fuzzy Synthetic Extent Value
FC1 (IO)	l1=0.13, m1=0.22, u1=0.38
FC2 (BF)	l2=0.21, m2=0.33, u2=0.50
FC3 (IQ)	l3=0.18, m3=0.30, u3=0.48
FC4 (CD)	l4=0.10, m4=0.15, u4=0.24

Using the Fuzzy synthetic extent value of criteria is used to calculate the degree of possibility (D). The degree of possibility shown in table 6 of D1(l1, m1, u1) >= D2(l2, m2, u2) is computed using equations 3, 4, and 5. The minimum DOP is found (shown in table 7), and they are ranked using equation 6.

Table 6:Degree of Possibility (DOP) for the criteria

DV(FC1>FCj)	DV(FC1)	DV(FC2>FCj)	DV (FC2)	DV(FC2>FCj)	DV (FC2)	DV(FC2>FCj)	DV (FC2)
DV(FC1>FC2)	0.61	DV(FC2>FC1)	1.00	DV(FC3>FC1)	1.00	DV(FC4>FC1)	0.59
DV(FC1>FC3)	0.72	DV(FC2>FC3)	1.00	DV(FC3>FC2)	0.90	DV(FC4>FC2)	0.11
DV(FC1>FC4)	1.00	DV(FC2>FC4)	1.00	DV(FC3>FC4)	1.00	DV(FC4>FC3)	0.27

Table 7: Minimum DOP for the criteria

Degree of Possibility	DV(FC1)	DV(FC2)	DV(FC3)	DV(FC4)
	0.61	1.00	1.00	0.59
	0.72	1.00	0.90	0.11
	1.00	1.00	1.00	0.27
Minimum DOP	0.61	1.00	0.90	0.11

FuzW` = (0.61, 1.00, 0.90,0.11)T

After calculating fuzzy weight using equation 6, normalized weight/non-fuzzy weight is calculated using equation 7.

FuzW = (0.233, 0.381, 0.343, 0.043)

After finding out the normalized weights of the criteria. Now, weights are compared, and these are ranked as mentioned in table 8.

Table 8: Comparison of weights and Ranking of Criteria

Criteria	Normalized Weights	Ranking of Criteria
IO	0.233	3
BF	0.381	1
IQ	0.343	2
CD	0.043	4

The above same process is done for all sub-criteria and ranked both relatively and globally, which is shown in table 9.

Table 9: Comparative weights and Ranking of Criteria and sub-criteria

Criteria	Relative Preference Weights	Relative Rank	Sub-Criteria	Relative Preference Weights	Relative Rank	Global Preference Weights	Global Rank
IO	0.233	3	AD	0.010	4	0.002	22
			CY	0.260	2	0.061	10
			EU	0.226	3	0.053	11
			PN	0.503	1	0.117	5
BF	0.381	1	EN	0.277	2	0.106	6
			AS	0.071	5	0.027	14
			CS	0.103	4	0.039	12
			NE	0.309	1	0.118	4
			OM	0.240	3	0.091	8
IQ	0.343	2	CN	0.083	6	0.029	13
			ES	0.037	7	0.013	16
			CL	0.281	4	0.096	7
			RL	0.245	5	0.084	9
			AE	0.354	3	0.121	3
			CLS	0.365	2	0.125	2
			PI	0.496	1	0.170	1
CD	0.043	4	WO	0.098	5	0.004	20
			SE	0.076	6	0.003	21
			FE	0.192	4	0.008	19
			WU	0.264	2	0.011	17
			LQ	0.370	1	0.016	15
			TL	0.228	3	0.010	18

5. Discussion and Conclusion

It is very tough to choose which factor of students' satisfaction level is more important than others while doing online education. When these factors are prioritized using a suitable and apt approach, it becomes easier, helpful, precise, and logical for the decision-makers. In the current study, FAHP has been used to prioritize the factors and high weightage value of Table 8, prioritizing the factors and results shows that BF, IQ, IO, and CD are in descending order. This shows uttermost importance is given to personality dimensions for online educational systems followed by instructor quality, ICT orientation, and course design, respectively. Further going in BF sub-factors, the ranking reported in table 9 is NE > EN > OM > CS > AS, and here least important sub-factor in the case of BF factor is agreeableness. Similarly, in the IQ sub-factor, PI is the highest weightage sub-factor, and ES is the lowest weightage sub-factor. However, CLS, AE, CL, RL, CN are in descending order (Table 9). IQ ratings are PI > CLS >AE > CL > RL > CN > ES that shows personalized interaction is the topmost sub-factor among this factor and among all other sub-factors. Similarly, for IO factors is PN > EU > CY > AD, which shows users' perception is the most important sub-factor. Among CD factors, LQ > WU> TL> FE > WO > SE that indicates different learning environment is the least important sub-factor. However, sub-factors ranking is PI-CLS-AE-NE-PN-EN-CL-OM-RL-CY-EU-CS-CN-AS-LQ-ES-WU-TL-FE-WO-SE-AD in descending order concerning their weights as mentioned in Table 9. The online education system should take care of these ranked sub-factors for achieving a higher student satisfaction level. In the future, several other techniques can be used instead of FAHP to counter the vagueness generated by expert opinions. Techniques like ELECTRE, FAHP+TOPSIS, AHP+TOPSIS, and DEMATEL can be explored in the future.

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Annexure A:

Factors with sub-factors

Factors	Sub-factors
ICT orientation	Advantage
	Compatibility
	Ease of Use
	Perception
Big-Five Personality Dimensions	Extraversion
	Agreeableness
	Conscientiousness
	Negative Emotionality
	Open-Mindedness
Instructor Quality	Communication
	Enthusiastic
	Concerned about student learning
	Respectful of student learning
	Accessible
	Comfortable learning space
	Personalized interactions
Course Design	Well organized
	Supports different learning environments
	Facilitated the course effectively
	Webinar usage
	Learn educational statistics quickly
	Take responsibility for learning