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A NEW MCDM APPROACH INTEGRATING QFD, DEMATEL WITH TOPSIS FOR EXPLORING THE EFFECT OF SOCIAL NETWORK USAGE ON ACADEMIC PERFORMANCE

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ABSTRACT

The rapid advances in internet applications Social Networking Sites (SNS) have become worldwide used internet applications and play a prominent role in student academic performance. In order to determine the evaluation criteria of SNS usage from the perspective of student academic performance, we have integrated multi-criteria decision making (MCDM) approaches: (a) Quality Function Deployment (QFD), (b) Decision Making Trial and Evaluation Laboratory (DEMATEL) and (c) Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) under fuzzy environment is proposed. In this method, the personality, cultural and technology criteria for determining SNS usage on academic performance is established. These three kinds of criteria are assessed from the student and the faculty perspective respectively. Students give their subjective responses about the importance of SNS usage and rating the alternatives with respective to academic performance. Similarly, faculty members give their subjective preferences about the relationship between personality, cultural and technology criteria and the correlation between SNS usage on academic performance of students. Further, the hybridization of QFD, DEMATEL, and TOPSIS has not been available in the literature. Based on this context, we have combined QFD, DEMATEL, and TOPSIS approach for evaluating SNS usage on academic performance from the perspective of university students in India. The proposed approach has been tested in a real case study among VIT university students in India. A numerical illustration for SNS usage on academic performance is also given to demonstrate the application of hybrid MCDM approach.

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KEY WORDS

Social Networking Sites (SNS); Academic Performance Criteria (AC); Fuzzy Multi-Criteria Decision Making (FMCDM); Quality Function Deployment (QFD); Decision Making Trial and Evaluation Laboratory (DEMATEL); Technique for Order Performance by Similarity to Ideal Solution (TOPSIS

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INTRODUCTION

Social Networking Sites (SNS) includes Facebook and Twitter is gaining popularity and widely used applications among Asian university students. In India, SNS sites are currently utilized by 120.5 million of users on (2014) the demand is estimated at 224.2 million of social network users in 2018, up from 63.1 million in 2012 [19]. Moreover, an earlier study revealed that more than 80% of university students have used Facebook, which is a vital element in university social culture [10]. The earlier studies [1, 3, 4, 6-8, 11-13, 16-18, 20, 21] have addressed the relationship between academic performance and SNS usage through various contexts such as personality (big-five personality factors), technology context (ICT tools) and cultural context (personal importance of SNS and motives of SNS usage). Consistent with the earlier research works, this study has integrated the SNS usage and student academic performance relationship in three contexts: *personality context* (big-five personality factors), *technology context* (ICT tools), and *cultural context* (personal importance of SNS and motives of SNS usage). However, a comprehensive approach for measuring personality, technology, and cultural factors for evaluating SNS usage with relate to student academic performance under fuzzy environment has not been adequately available in the literature. Subsequently, fuzzy multi-criteria decision making for integrating QFD, DEMATEL, and TOPSIS for validating SNS usage on academic performance was not reported in the literature. Thus, to address this research gaps motivated us to develop a combined approach based on QFD-DEMATEL-TOPSIS under fuzzy environment is presented in this study.

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To address these research gaps, an empirical study has been carried out in VIT University, India to evaluate SNS usage effectiveness from the perspective of student academic performance. The rest of this paper is organized as follows: Section 2 presents the literature reviews on SNS criteria and it measurements have been used in this study. Sections 3 present the QFD-DEMATEL-TOPSIS approach and assessment framework used in this research. Section 4 and 5 presents the empirical study results and a discussion of the study respectively. A conclusion of the study is presented finally to address the significance of QFD-DEMATEL-TOPSIS to address the SNS effectiveness.

LITERATURE OF PAST RESEARCH WORKS

This section presents the earlier researches and constructs an assessment methodology that is used in this study.

Personality, cultural, and technology context for SNS usage on academic performance

Earlier research studies have addressed the personality context through big-five personality factors (extraversion, neuroticism, agreeableness, openness to experience, and conscientiousness) to measuring SNS usage on academic performance [7, 11-13,16-18]. Consistent with previous research works, this study has addressed personal characteristics from the perspective of SNS effectiveness on student academic performance through big-five indictors. In technology context, earlier studies [4, 14, 15] have investigated the use of ICT in SNS and its positive outcome in educational settings. Further, the research relating SNS and integrate the use of ICT tools that support for SNS has been addressed by few studies. Besides, in technology context the focus of this study has revealed the SNS and integrates use of ICT towards academic performance. In cultural context, many of the researchers [6, 8, 15, 17, 20] have addressed the cultural difference and the motivations behind the usage of SNS towards the academic performance. Based on this context, the cultural aspects have been evaluated for SNS effectiveness on student academic performance addressed in this study via two dimensions: personal importance of SNS and motives for SNS usage. The source of measurements and possible evaluation criteria's of SNS effectiveness on academic performance are collectively determined through earlier literature [1, 3, 4, 6-8, 11-18, 20, 21, 27] as follows:

Table: 1. Summary of source of measurements and possible evaluation criteria's of SNS effectiveness on academic performance

Personality Context*(Extraversion, Neuroticism, Agreeableness, Openness to new Experience, Conscientiousness)*
Does extraversion motivate you to form new connection that improves your academic performance through SNS?
Do you think extraverts perform better in academics than introverts?
Does being an extrovert help you in gaining more knowledge through SNS?
An extrovert joins more online groups to gain knowledge?
Does Neurotic people find SNS environment to be less anxiety provoking than everyday classroom studies?
Does SNS helps introvert and neurotics students to reach their full potential regarding interaction with their peers and professors?
Does SNS helps neurotic student to share their idea more freely on SNS?(Yes/No)
Does SNS helps in collecting more people who agrees for same ideology in studies?
To what extent you have found users which engage and endorse interpersonal cooperation easily in studies?
Do you find agreeable individual more cooperative, trusting, and helpful?
Do you think SNS to be innovative in field of education?
Do you think SNS to be better means of education than others?
Are you willing to accept SNS as an educational tool?
Does less conscientiousness student spent more time using SNS and achieve better results in education?
Does conscientious individuals are likely to be high achievers as they have a strong work ethic?
Cultural Context *(Personal Importance of SNS and motives for SNS use)*
Do you find any information regarding your career or academic interests on social networking sites?
Do you think social networking sites can be an effective tool for e-learning?
Do you think social networking sites are more effective in communicating with your teachers than in actual class?
Do you think social media sites improve your academic performance?
Do you prefer to express your ideas and feelings on social networking sites?
Technology Context *(ICT tools)*
Does student feel more comfortable in adapting new ICT technology?
Do you find ICT tools helpful for easily access to SNS?
Academic Performance
Are Reflective learning styles include synthesis-analysis and elaborative processing more effective than agented learning styles include methodical study and fact retention?
Do reflective learning styles (synthesis-analysis and elaborative processing) facilitate deeper understanding?
Do you think openness is most beneficial to learning when students adopt reflective learning styles?
Do you think both personality traits and learning styles are influencing with academic achievement?

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The panel of experts has validated the questionnaires and finalized these factors as evaluation criteria to validate SNS usage effectiveness on student academic performance under this study as shown in **Table– 1**.

Table: 2. Linguistic Terms

Linguistic Variable	Corresponding TFN Multiplicative/Fuzzy	Crisp Value
Strongly agree	(3,4,5)/(0.9,1.0,1.0)	5/1.0
Agree	(2,3,4)/(0.7,0.9,1.0)	4/0.9
Neither Disagree Nor Agree	(1,2,3)/(0.3,0.5,0.7)	3/0.7
Disagree	(0,1,2)/(0.0,0.1,0.3)	2/0.3
Strongly Disagree	(0,0,1)/(0.0,0.0,0.1)	1/0.1

QFD, DEMATEL and TOPSIS

Currently, there is an interest to use fuzzy QFD or House of Quality (HOQ) in multi-criteria decision making approaches. In this paper SNS usage on student academic performance has been categorized in to QFD matrixes (often HOQ) has been applied to determine the importance of parameters. Similarly, the earlier studies [5, 9] have been given a combined methodology of group decision making based on fuzzy linguistic variables for QFD applications. Based on this context, this study has employed QFD and MCDM approaches for measuring SNS usage on academic performance of university students.

Recently, fuzzy DEMATEL approach has been used for evaluation of attributes, interrelationship among the criteria and especially dealing with human uncertainty and subjective vagueness within the decision making process by the use of fuzzy set theory. In the recent studies [22, 24, 25] DEMATEL approach has been investigated in different areas of application in the context of MCDM problems. Likewise this research focuses on DEMATEL approach on designing hybrid methodology for the real data set obtained from VIT University for evaluating SNS usage effectiveness on student academic performance is presented.

TOPSIS, one of the conventional MCDM methods, has been widely used to compute the relative importance of alternatives and solving practical decision making problems with its high computational efficiency and comprehensibility. Moreover, current studies have adopted TOPSIS to solve MCDM problems [2, 24, 26]. Similarly, the basic idea of using TOPSIS in this paper is to compute the ideal solution (best values realistic of criteria) and negative ideal solution (worst values realistic of criteria) for ranking the SNS usage on academic performance factors perceived by university students.

To the best of our knowledge, up to date research on evaluation of SNS usage on academic performance case study under fuzzy environment is very limited. Moreover, assessment framework for the integration of personality, cultural and technology factors for the effectiveness of SNS usage on academic performance has not been adequately presented in the available literature. Further, the hybridization of QFD, fuzzy DEMATEL, and TOPSIS has addressed only in very few studies. Based on this context we have integrated QFD-DEMATEL-TOPSIS approach for evaluating SNS usage on academic performance from the perspective of university students in India.

FRAMEWORK FOR EVALUATING SNS USAGE ON ACADEMIC PERFORMANCE IN FUZZY ENVIRONMENT

In this study, the QFD approach has been integrated with the fuzzy DEMATEL and TOPSIS approach for the evaluation of SNS usage effectiveness on students' academic performance from the perspective of personality, cultural and technology contexts under a fuzzy environment is proposed.

The proposed QFD-DEMATEL-TOPSIS methodologies for SNS usage on academic performance evaluation framework consists of three parts. First, we have used QFD approach for determine the importance of parameters in the respective contexts. Second, we have applied the DEMATEL approach for determining the weights of the SNS criteria. Finally, we have used fuzzy TOPSIS to identify the rank and significance of the SNS attributes from the perspective of student academic performance.

The construction of proposed framework and computation procedure of hybridization of QFD-DEMATEL-TOPSIS approach under a fuzzy environment is depicted in **Figure –1**.

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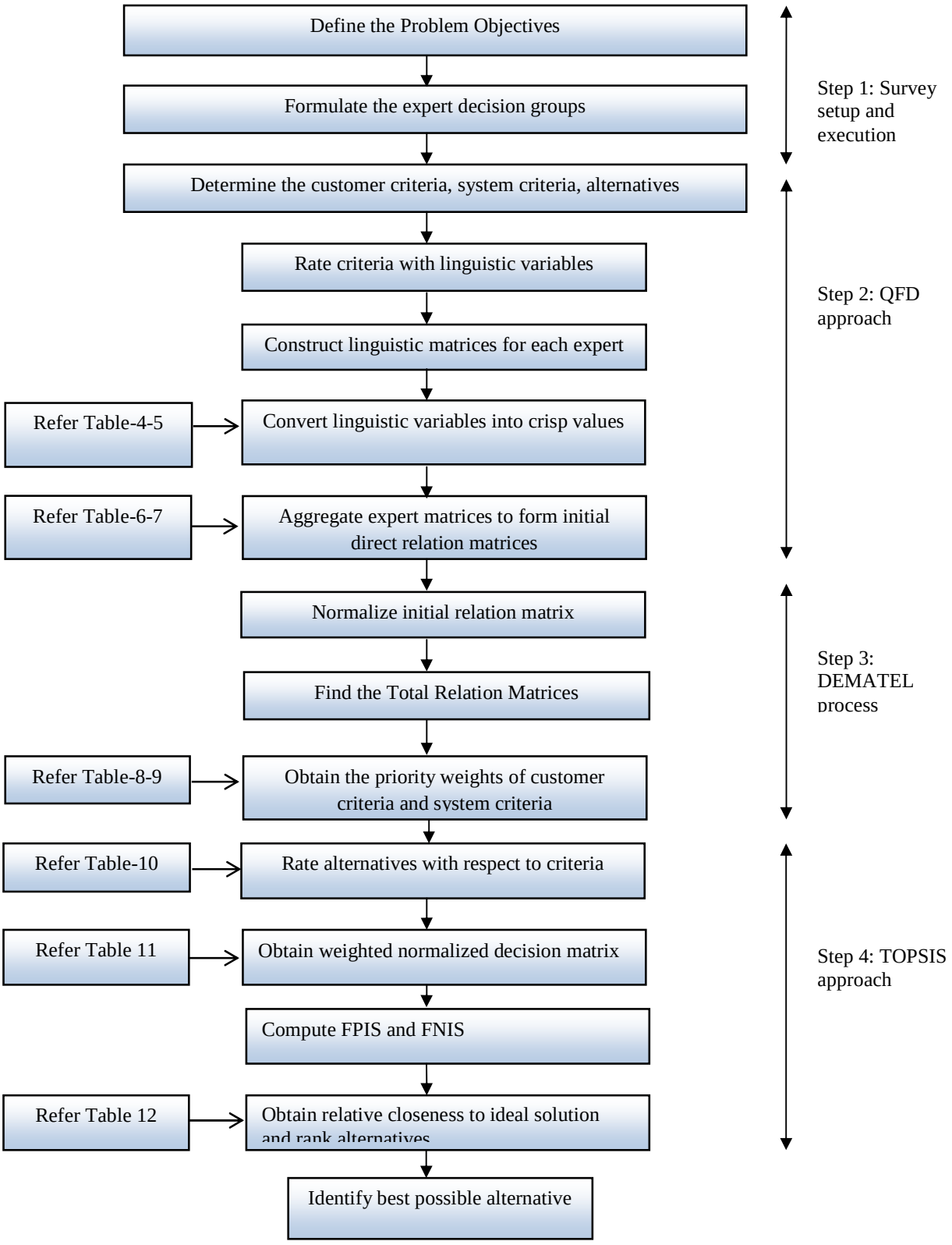

Fig: 1. Proposed technique for evaluating SNS effectiveness on academic performance

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EMPIRICAL CASE STUDY FOR EVALUATING THE SNS EFFECTIVENESS ON ACADEMIC PERFORMANCE

The main focus of this study is to determine the SNS usage effectiveness at individual, cultural and technology levels in academic performance research phenomenon of university students. To achieve this goal, an empirical study has been carried out in VIT University students located in India. The demographic details of the respondents of this study were undergraduate science, engineering students, and faculty members of VIT University. Two groups of student, S1 and S2, and two groups' faculty, F1 and F2 were approached for representation of their fuzzy preferences. Consequently, the empirical study has been tested among 40 DMs' (20 students and 20 faculties) of this organization to validate the effectiveness of SNS usage on academic performance. According to earlier study [2], we have followed fuzzy preference and multiplicative preference relations for DM's judgments over set of alternatives/criteria. The hybrid fuzzy QFD-DEMATEL-TOPSIS approaches were applied in this case study, as illustrated in the following sections.

Quality function deployment application

The basic steps of QFD approach used in this study are as follows:

Step 1: Identify the alternatives, student personality criteria, and academic performance criteria. The identified criteria are as follows:

Table: 1. Criteria for evaluation of SNS usage effectiveness

Criteria	Code	Description
Personality criteria		
Extraversion	**SC1**	Effectiveness of extraversion on SNS usage on academic performance
Neuroticism	**SC2**	Effectiveness of neuroticism on SNS usage on academic performance
Conscientiousness	**SC3**	Direct and positive effect of conscientiousness on SNS usage on academic performance
Agreeableness	**SC4**	Positive effect and agreeableness on SNS usage on academic performance
Openness to experience	**SC5**	Previous and openness to experience on SNS usage on academic performance
Academic Performance criteria		
ICT Tools	**AC1**	Effectiveness of ICT tools usage of SNS on academic performance
Personal Importance of SNS	**AC2**	Effectiveness of personal importance on SNS usage on academic performance
Motives of SNS Usage	**AC3**	Direct positive effect and motives of SNS usage on academic performance

Step 2: Construct the relational matrices and linguistic weight matrices based on the DM's ratings. The matrices, after converting to crisp values have been represented **[Table–4 and -5]**

Step 3: The rating matrices are aggregated to determine corresponding weights.

Fuzzy DEMATEL application

Step1: The initial direct-relation matrices are obtained from the QFD application and are represented **[Table–6 and -7]**.

Step2: The initial direct relation matrices D1 and D2 are normalized by equations (1)-(2) to form normalized matrices N1 and N2.

$$m = max_{1 \le i \le n} \sum_{j=1}^{n} d_{ij} \quad (1)$$

$$N = \frac{1}{m} D \quad (2)$$

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Step3: The total relation matrices R1 and R2 are computed by the following equation.

$$R = N(I - N)^{-1} \quad (3)$$

Step4: Weights of customer criteria and system criteria are computed using the equations (4)-(6)

$$r_i = \sum_{1 \le j \le n} R_{ij} \quad (4)$$

$$c_j = \sum_{1 \le i \le n} R_{ij} \quad (5)$$

$$W_j = \sum_{j=1}^{n}(r_i + c_i) / \sum_{i=1}^{n}\sum_{j=1}^{n}(r_i + c_i) \quad (6)$$

The priority weights for student criteria (SC) and academic performance criteria (AC) are tabulated in **Table–8 and Table–9** respectively.

Fuzzy TOPSIS Application

The basic steps of Fuzzy-TOPSIS approach used in this study are as follows:
Step 1: Construct fuzzy assessment decision matrix, determine the alternatives, and normalize the scores in order to find the best alternative **[Table–10].**

Step 2: Input the weights which is obtained from the DEMATEL method to calculate the weighted normalized decision matrix as given in **Table–11.**

Step 3: The best evaluation and worst evaluation value with respect to each criterion is determined through FPIS and FNIS.

Step 4: Obtain relative closeness coefficient to the ideal solution and rank the alternatives **[Table–12].**

RESULTS

The numerical results of the empirical study have been illustrated as follows:

Table: 2(a). Relation between student criteria rated by Student S1

Criteria	SC1	SC2	SC3	SC4	SC5
SC1	0.5	0.65	0.6	0.4	0.65
SC2	0.35	0.5	0.65	0.9	0.65
SC3	0.4	0.35	0.5	0.15	0.15
SC4	0.6	0.1	0.85	0.5	0.65
SC5	0.35	0.65	0.85	0.35	0.5

Table: 3(b). Relation between student criteria rated by student S2

Criteria	SC1	SC2	SC3	SC4	SC5
SC1	0.5	0.55	0.3	0.4	0.65
SC2	0.45	0.5	0.3	0.9	0.35
SC3	0.7	0.7	0.5	0.15	0.65
SC4	0.6	0.1	0.85	0.5	0.65
SC5	0.35	0.65	0.35	0.35	0.5

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Table: 4 (c). Relation between student criteria rated by faculty F1

Criteria	SC1	SC2	SC3	SC4	SC5
SC1	0.5	0.4	0.2	0.9	0.7
SC2	0.2	0.5	0.6	0.9	0.7
SC3	0.3	0.1	0.5	0.8	0.5
SC4	0.8	0.2	0.7	0.5	0.3
SC5	0.2	0.1	0.2	0.6	0.5

Table: 4 (d). Relation between student criteria rated by faculty F2

Criteria	SC1	SC2	SC3	SC4	SC5
SC1	0.5	0.8	0.4	0.1	0.7
SC2	0.2	0.5	0.6	0.9	0.7
SC3	0.7	0.8	0.5	0.9	0.5
SC4	0.8	0.2	0.7	0.5	0.6
SC5	0.2	0.2	0.2	0.6	0.5

Table: 4(a). Relationship between academic performance criteria rated by student S1

Criteria	AC1	AC2	AC3
AC1	0.5	0.3	0.6
AC2	0.7	0.5	0.35
AC3	0.4	0.65	0.5

Table: 5(b). Relationship between academic performance criteria rated by student S2

Criteria	AC1	AC2	AC3
AC1	0.5	0.3	0.6
AC2	0.7	0.5	0.35
AC3	0.4	0.65	0.5

Table: 5(c). Relationship between academic performance criteria rated by faculty F1

Criteria	AC1	AC2	AC3
AC1	0.5	0.5	0.3
AC2	0.3	0.5	0.4
AC3	0.4	0.5	0.5

Table: 5(d): Relationship between academic performance criteria rated by faculty F1

Criteria	AC1	AC2	AC3
AC1	0.5	0.5	0.3
AC2	0.3	0.5	0.4
AC3	0.4	0.5	0.5

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Table: 6. Aggregated relationship between student criteria

Criteria	SC1	SC2	SC3	SC4	SC5
SC1	0.5	0.6	0.375	0.45	0.675
SC2	0.3125	0.4625	0.5375	0.9	0.6
SC3	0.525	0.5	0.5	0.5	0.45
SC4	0.7	0.65	0.775	0.5	0.55
SC5	0.275	0.4	0.4	0.475	0.5

Table: 7. Aggregated relationship between academic performance criteria

Criteria	AC1	AC2	AC3
AC1	0.5	0.4	0.45
AC2	0.5	0.5	0.375
AC3	0.4	0.575	0.5

Table: 8. Priority weights of student criteria

Criteria	Weight
SC1	0.3780
SC2	0.4219
SC3	0.3774
SC4	0.4451
SC5	0.3775

Table: 9. Priority weights of academic performance criteria

Criteria	Weight
AC1	0.667
AC2	0.661
AC3	0.673

Table: 10. Fuzzy rating of alternative with respect to criteria

	SC1	SC2	SC3	SC4	SC5	AC1	AC2	AC3
A1	(0.2,0.3,0.7,0.8)	(0.1,0.4,0.7,0.8)	(0.3,0.7,0.8,.9)	(0.1,0.3,0.7,0.5)	(0.5,0.6,0.8,1)	(0.4,0.5,0.8,1)	(0.3,0.7,0.8,1)	(0.2,0.5,0.8,1)
A2	(0.1,0.4,0.7,0.9)	(0.3,0.7,0.8,.9)	(0.2,0.5,0.8,1)	(0.1,0.5,0.8,0.9)	(0.2,0.5,0.8,1)	(0.2,0.3,0.7,0.8)	(0.5,0.6,0.8,1)	(0.2,0.3,0.7,0.9)
A3	(0.3,0.5,0.7,0.8)	(0.2,0.5,0.8,1)	(0.5,0.6,0.8,1)	(0.3,0.7,0.8,.9)	(0.2,0.3,0.7,0.8)	(0.1,0.5,0.8,0.9)	(0.2,0.3,0.5,0.9)	(0.5,0.6,0.8,1)
A4	(0.4,0.7,0.8,.9)	(0.5,0.6,0.8,1)	(0.2,0.6,0.7,0.8)	(0.2,0.6,0.7,0.8)	(0.5,0.6,0.8,1)	(0.3,0.6,0.8,1)	(0.2,0.5,0.8,1)	(0.5,0.6,0.8,1)
A5	(0.1,0.5,0.8,0.9)	(0.3,0.8,0.7,1)	(0.1,0.4,0.7,0.9)	(0.1,0.5,0.8,0.9)	(0.3,0.8,0.7,1)	(0.2,0.5,0.8,1)	(0.5,0.6,0.8,1)	(0.3,0.8,0.7,1)

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Table: 11. Weighted normalized matrix

	Benefit criteria					Cost criteria		
	SC1	SC2	SC3	SC4	SC5	AC1	AC2	AC3
A1	0.1465	0.1455	0.1807	0.1402	0.1849	0.3286	0.3148	0.3070
A2	0.1538	0.1964	0.1673	0.2015	0.1594	0.2434	0.3260	0.2579
A3	0.1685	0.1819	0.1941	0.2366	0.1275	0.2799	0.2136	0.3561
A4	0.2051	0.2110	0.1539	0.2015	0.1849	0.3286	0.2810	0.3561
A5	0.1685	0.2037	0.1405	0.2015	0.1785	0.3043	0.3260	0.1965

Table: 12. Ranking of alternatives

Alternative	Relative closeness to ideal solution	Rank
A1	0.72	1
A2	0.48	4
A3	0.51	3
A4	0.61	2
A5	0.44	5

DISCUSSION

The integrated QFD-DEMATEL-TOPSIS methodology has been used for investigation of SNS usage on the academic performance of students from Asian countries and especially in VIT University, India. The data used in this study were collected from faculty and students of VIT University to explore the SNS usage on academic performance through survey questionnaires. The faculty and students have given their subjective judgments based on multiplicative preference/fuzzy preference relations as shown **Table– 3**. Totally 4 (5 alternatives) DMs' samples are represented in this study to explore the SNS effectiveness criteria using linguistic assessments on fuzzy preference/multiplicative preference relation. In addition, **Tables 6 and 7** depicts the aggregation of DMs ranking of each alternative with respect to criteria on Table-3 using fuzzy linguistic items as shown in **Table–2**. Subsequently, the relative importance of the criteria and output of QFD modeling has been represented in **Tables–8 and 9**. The weights of DEMATEL results address that Agreeableness (SC4) and Motives of SNS usage (AC3) are more significant that those other evaluation factors. Consequently, the QFD-DEMATEL modeling results have been applied in the TOPSIS method and their results are given in **Tables– 10-12**. From the above results, it can be concluded that alternative A1 is closest to the ideal solution while alternative A5 is farthest from it. Thereby, SNS usage on university students can facilitate the effectiveness of student learning performance in academic organizations.

CONCLUSION

The main objective of this paper is to provide an approach to evaluate SNS effectiveness on from the student academic performance perspective. In order to do that, a new MCDM approach combining QFD-DEMATEL-TOPSIS has been proposed in the fuzzy environment. Moreover, this proposed approach has been investigated among VIT University students to explore the influence of SNS effectiveness in academic performance. Furthermore, to demonstrate the applicability and creditability of QFD-DEMATEL-TOPSIS approach, the framework has been validated based on the data collected from the VIT university students. Consequently, this study has presents two valuable contributions: (i) a comprehensive overview of the factors influencing SNS usage on academic performance (ii) QFD-DEMATEL-TOPSIS approach to find the relative importance of the criteria and to rank the criteria. In this study, we have suggested a research framework based on QFD-DEMATEL-TOPSIS which can effectively validate and rate the SNS evaluation criteria in the context of students' academic performance. Subsequently, the case study results address that personality, technology, and cultural context factors have a significant impact on the evaluation of the SNS effectiveness of student academic performance in the academic environment. The prototype of proposed approach (QFD-DEMATEL-TOPSIS) can be developed in the future it can be enhanced into an efficient tool to handle MCDM in a real time settings.

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Through MCDM approach we have revealed that SNS and its influential factors are the main contributors to enhance student learning performance in an academic setting.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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