



# Neutrosophic Environment and E-Learning: An Investigation into Student Satisfaction and Attitudes in the College of Engineering

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## Abstract

Ever since the transition to online learning, students from across the globe have familiarized themselves with the use of e-learning. This research paper aims to investigate students' attitudes towards e-learning and measure students' level of experience in using the e – system among students in the College of Engineering in the United Arab Emirates (UAE). Furthermore, this paper explores the predictors of students' perceived satisfaction with the e-learning system quality that is integrated to facilitate e-learning. Descriptive analysis and stepwise multiple regression were chosen to achieve the paper's objectives. Data analysis demonstrated that Engineering students showed a positive attitude towards the e-learning system and were identified with high self-efficacy and a high level of experience in using the e-learning system. In addition, multimedia instructions, self-efficacy, and e-learning system quality were found as significant predictors of students' satisfaction with the e-learning system; however, the interactive learning activities as a predictor of perceived satisfaction did not reveal any statistical significance. Also, this paper used the DEMATEL method to analysis the student attributes and compute the weights of the attributes. The DEMATEL method is a MCDM method due to the attribute of student are neuromas so the concept of the MCDM is used. The DEMATEL method integrated with the neutrosophic sets. The neutrosophic sets is used to overcome the uncertainty and the vague data.

**Keywords:** E-learning; Engineering students; self-efficacy; e – system quality; e-learning effectiveness; Neutrosophic Sets; DEMATEL; MCDM

## 1. Introduction

The concept of a neutrosophic environment is a relatively new area of research that has gained increasing attention in recent years. Neutrosophy is a branch of philosophy that deals with the study of concepts that are indeterminate or have a degree of uncertainty. In the context of e-learning, a neutrosophic environment is one where there is a significant level of ambiguity or uncertainty in the learning process. This can arise due to factors such as the use of new technologies, unfamiliar learning methodologies, or a lack of interaction with instructors and peers. The aim of this study is to explore the impact of a neutrosophic environment on student satisfaction and attitudes towards e-learning in the context of the College of Engineering. By investigating the factors that contribute to a neutrosophic environment and their relationship with student satisfaction and attitudes, this study aims to provide insights that can be used to improve the quality of e-learning experiences in the College of Engineering and beyond. Distance education is not a new concept, it is widely recognized as the alternative delivery system where students and educators are separated by distance. With the spread of the internet and advanced technology, e-learning became one of the most important methods of instructional design and content delivery as it can provide efficient education at a low cost. Moreover, access to e-learning classes is many ways easier than face – to face classes, hence it can be accessed anytime and anywhere [1, 2]. However, since March 2020 and after the announcement of

World Health Organization (WHO) that COVID-19 outbreaks became a global pandemic, online and distance learning become the only solution for the continuation of education and learning all over the world with considering safety measures. The sudden transition to online learning necessitates understanding some factors that could influence the nature of e-learning process. These factors include multimedia instructions the transformation from face-to-face to online learning, learners' e-self-efficacy and readiness to accept the e-learning form.

Engineering education is based on science and mathematics makes it significantly different from other disciplines. These scientific subjects are traditionally challenging to teach online because of the need for laboratories, equation manipulation, and hands on activities. However, the Learning Management System (LMS) and advanced technology tools facilitate online education. Achieving the online learning objectives requires focusing on many factors that contribute to its success. These factors include e-system quality, students' perception, self-efficacy and satisfaction, interactive learning activities, and students' behavioral intention to learn and interact virtually. Many research studies [3, 4, 5, 6] focused on the Engineering education, however the research on this area in the United Arab Emirates (UAE) is not sufficient, so there is a need to fill this gap to enhance the online Engineering education and present effective practices and implications.

The current research study aims to achieve the following objectives (1) Assessing the perception and attitudes of College of Engineering students in the UAE during the transition to the e-learning education, (2) Examining students' level of experience in using e-learning system in College of Engineering, and (3) Exploring the most dominant predictors of students' perceived satisfaction about the e-learning system. For this study e-learning system refers to the **Blackboard** as a Learning Management System (LMS) that is used by most of College of Engineering in the UAE. The findings of this research study will benefit the higher education system in terms of designing appropriate interactive e-learning activities to strengthen the learning in the UAE. From the global perspectives, the findings will present an addition to the body of knowledge about the e-learning in the Gulf area as a multicultural environment that host people from different ethnicities across the globe. The findings will introduce beneficial recommendations for best practices to enhance the e-learning for Engineering education.

## 1.2 Theoretical framework

The current study considers the theoretical framework proposed by Liaw and Huang [7]. *Liaw and Huang suggest a four-elements model to be considered when discussing and facilitating e-learning environment. The four elements are (1) environmental characteristics*, which refers to *e-learning system quality and multimedia instruction, synchronous or asynchronous interaction to communicate effectively*, (2) *environmental satisfaction* is measured by students' satisfaction about the e-learning environment and their perceptions of technology that might enhance their contribution to the learning processes (3) *learning activities* refer to *interactive learning activities* and students' engagements on e-learning environment to promote knowledge sharing between instructors and students, and (4) *learners' characteristics* mean *learners' self-efficacy*, the ability to deal with the e-system adequately. [7] believed that when learners do not have enough competency, or feel less self-confident toward information e-environment, they are expected to show fewer positive feelings toward the e-system.

For this study, assessing students' perceptions and attitudes toward e-learning measured and explained in the context of Liaw model[8], which contains 8 domains. The domains are *Perceived self-efficacy, Perceived satisfaction, Perceived usefulness, Behavioral intention, e-learning system quality, interactive learning activities, e-learning effectiveness, and multimedia instruction*. In this paper, the researchers are hypothesizing that students' satisfaction will be based on four dimensions; *e-learning system quality, interactive learning activities, multimedia instructions*, and students' *self-efficacy* as measured by [8].

Based on the activity theory, when students are engaged in learning activities, learning outcomes such as problem-solving skills and critical thinking abilities are expected to be [9]. Moreover, multimedia instructions and interactive communication boost students' engagement which will enhance learning outcomes [10].

The used data set may include hazy, vague, indeterminate, or hesitant information; hence, several sorts of fuzzy set extensions are used in order to deal with the uncertainty. When it comes to classical set theory, an element may either belong to a set or not; when it comes to optimization, a solution can either be feasible or not; and when it comes to Boolean logic, a statement can either be true or false, but not anything in between[11]. However, given the circumstances of actual life, nearly nothing is exact, and everything is a question of degree; thus, it is impossible to define anything using conventional reasoning. Zadeh came up with the fuzzy sets theory so that people may find a way to cope with uncertainty of this nature. Since its inception in 1965, it has been developed further and expanded into a variety of forms [12, 13]. Again, Zadeh is the one who came up with the idea of using fuzzy sets to improve the representation of imprecision in mathematical operations. This time, he used type-2 fuzzy sets. Then, in 1986, Atanassov presented the idea of intuitionistic fuzzy sets. This is a notion that simultaneously incorporates membership and non-membership degrees [14]. Then, Smarandache presents neutrosophic sets, which provide a domain area that is made up of three separate subsets to express different kinds of uncertainty. Neutrosophic sets are defined as sets where every component in the universe has a level of truthiness, indeterminacy, and falsehood. Neutrosophic sets are also known as neutrosophical subsets[15, 16]. In the

neutrosophic sets, impreciseness is denoted as truth and falsity operations, but the indeterminacy function represents degrees of belongingness and non-belongingness and differentiates between absoluteness and relativeness. Neutrosophic sets are able to deal with the unpredictability of the system and cut down on the paralysis brought on by conflicting information thanks to this notation. As a result, one might argue that this capacity is the single most significant benefit offered by neutrosophic sets in comparison to the many other forms of fuzzy extension [17]. By making use of these three functions, neutrosophic sets are able to create a domain area. This area makes it possible for various kinds of mathematical operations to be carried out separately despite the presence of uncertainty [18, 19]. The DEcision MAKing Trial and Evaluation Laboratory (DEMATEL) approach is one of the decision making methods that is extensively used when there is interdependence among the choice criteria. This method was first presented by Fontela and Gabus [20, 21].

## 2. Related Work

### 2.1 Perceptions and Attitudes towards E – learning

As stated by McAndrew and Johnston in 2012 “E-learning and online learning adoption and implementation are no longer in question, as e – learning is the platform for education in the coming era” [22], However, to achieve the required educational learning outcomes and competent graduates, assessing, evaluating as well as supporting learners are very important concerns [23]. [24] examined students’ perceptions of integrating e – learning in two undergraduate business courses. The results showed that participants rated the online modules significantly positive. Accordingly, the authors suggested integration of e – learning into some courses based on learner characteristics, course content, and the learning context [24].

[25] included 2196 students from 29 universities in Austria in survey, to highlight the important aspects considered by students for their learning achievements and course satisfaction during e-learning. The study’s results showed a direct relation between instructor’s experiences and learning achievement as well as course satisfaction. Moreover, they showed that learning achievements related directly to self – regulated and collaborative learning. The study suggested the announcement of clear instruction to inspire students’ motivation and goals. On the other hand, the study emphasized the importance of instructors training [25].

In the study conducted by [26] in Saudi Arabia to evaluate the students’ perception and attitude towards e – learning. The authors distributed a 5 – points Likert scale questionnaire to undergraduate dental students when they were at their 4th year in 2014 and named as group 1, and during their internship year in 2017 and named as group 2. The study evaluated students’ computer skills, online skills, technological access as well as their motivation to use e – learning techniques for personal and learning purposes. The results of both groups showed high levels of computer skills, technological access as well as importance of online technology. However, they showed acceptable levels of e – learning for personal and learning purposes [26]. [27] examined students’ perception of online learning in Indonesia Open University to assess student – learning perceptions, regardless of the course delivery method and the online environment. The study compared between online and face to face learning, in term of social presence, social interaction, and satisfaction. The results revealed high students’ perception for face-to-face learning in the studied context. Furthermore, some students preferred e – learning as it helps them to be more innovative and develop e – skills. Additionally, this study showed that there is no statistical difference between students in learning preference. The same findings have been indicated by [28] when they investigated students’ perception for online and face to face learning on a sample of 156 students enrolled in Recreation and Tourism course in Northern California, United States.

[29] investigated undergraduate students’ perceptions, attitudes, and willingness to distance learning in three different countries namely Portugal, UAE, and Ukraine. The results showed that time management, motivation, and language skills were the main students concern and that make them anxious to some extent. Despite that student found distance learning interesting, thus, authors reported that each institution should develop its plan according to the needs of the students and staff [29]. Many researchers focused on Recommendation and suggestion from different research [30, 31, 32, 33] exploring students’ perceptions, attitudes and willingness to e-learning highlighted, their research suggested the following points:

- Importance of conducting readiness assessment to distance learning by distributing surveys to the students.
- Encouraging the students to speak with counselors regarding the distance learning.
- Preparation and offering of pre distance learning courses based on the students’ feedback and concern will enhance students’ skills attitudes.
- Organizing different activities to train and develop the instructors’ skills, to overcome distance learning difficulties in term of student engagement, motivation and time management.
- Offer hybrid courses that contains both online and face to face modules to prepare students for distance learning transition.

Integrating the TOPSIS with the single-valued neutrosophic set was the method that Wu and Fang [34] used in their research to develop a multilevel assessment framework for the teaching quality in higher education. The teaching performance as well as the learning results of the students were included into an indicator system that

was developed. An SVNS representation approach was suggested for the values of the qualitative indicators. This was done with the intention of describing the uncertainty, which in turn would increase the credibility and validity of the assessment. The TOPSIS-based multilevel assessment system, which comprised of an overall evaluation as well as five specialised evaluations, was then applied to both the qualitative data as well as the quantitative data.

### **2.2 Online learning in Engineering; communication and students' engagements**

Engineering Education (EE) is totally different from other disciplines, as it based mainly on mathematics and equation manipulation as well as sciences and laboratories. Information Computer Technology (ICT) implemented in EE to deliver classroom lectures and demonstrate laboratory experiments. Delivery of classroom lectures and laboratory experiments done by presentation that contains different items for better lesson's understanding such as presentations, diagrams, flowcharts, animations, visualization, videos and simulation.

Further enhancement in engineering education can be occurred by implanting e-learning, as it will enable the use of e-resource, online courses, lecture management systems, and collaboration tools [35]. Research studies conducted by [36, 37, 38] demonstrated that required competencies for engineers as identified by Accreditation Board for Engineering & Technology (ABET) can be boosted using e-learning. However, the breadth, penetration, and depth of e-learning education in EE differs among nations and engineering institutions despite its need.

[35] investigated the use of e-learning for different engineering programs with multi component curriculum including theory, practical, seminar and project. The investigated engineering institutions were in the state of Jammu and Kashmir. The study showed that instructional material of EE should be developed to suit e-learning structure and this one of the main challenges. Another challenge is the priorities of different factors that has an influence on technology integration, those factors are differ from institution to institution [35].

According to [39], implementing e-learning for EE will address two vital questions to engineers; first question was regarding the important of practical hands-on experience and can laboratory experiment achieve in an online education?

The second question was regarding the assessment of the accreditation organization for online program, how this organization can assess the required knowledge and skills for engineering graduate to begin professional practice?

One of the objectives of ABET as an accreditation organization is to ensure quality while encouraging innovation, and e-learning can be considered as a type of innovation [40], therefore, understanding the role and objective of engineering courses and experimental laboratories in the traditional education process will permits the design and develop of an innovative alternative means to achieve the desired output [41].

[42] studied the effect of the sudden shifting of teaching from traditional education to virtual classes due to COVID – 19. The study was applied on the college of Architecture engineering, Dar Al-uloom university, Saudi Arabia. The study was based on a survey distributed among architecture's students; the students' feedback highlighted the major difficulties faced the students due to the sudden transitions [42]. One of the main Students' challenges in distance learning is the student participation and engagement. It includes different category as reported by [43, 44, 45] and summarized in figure 1

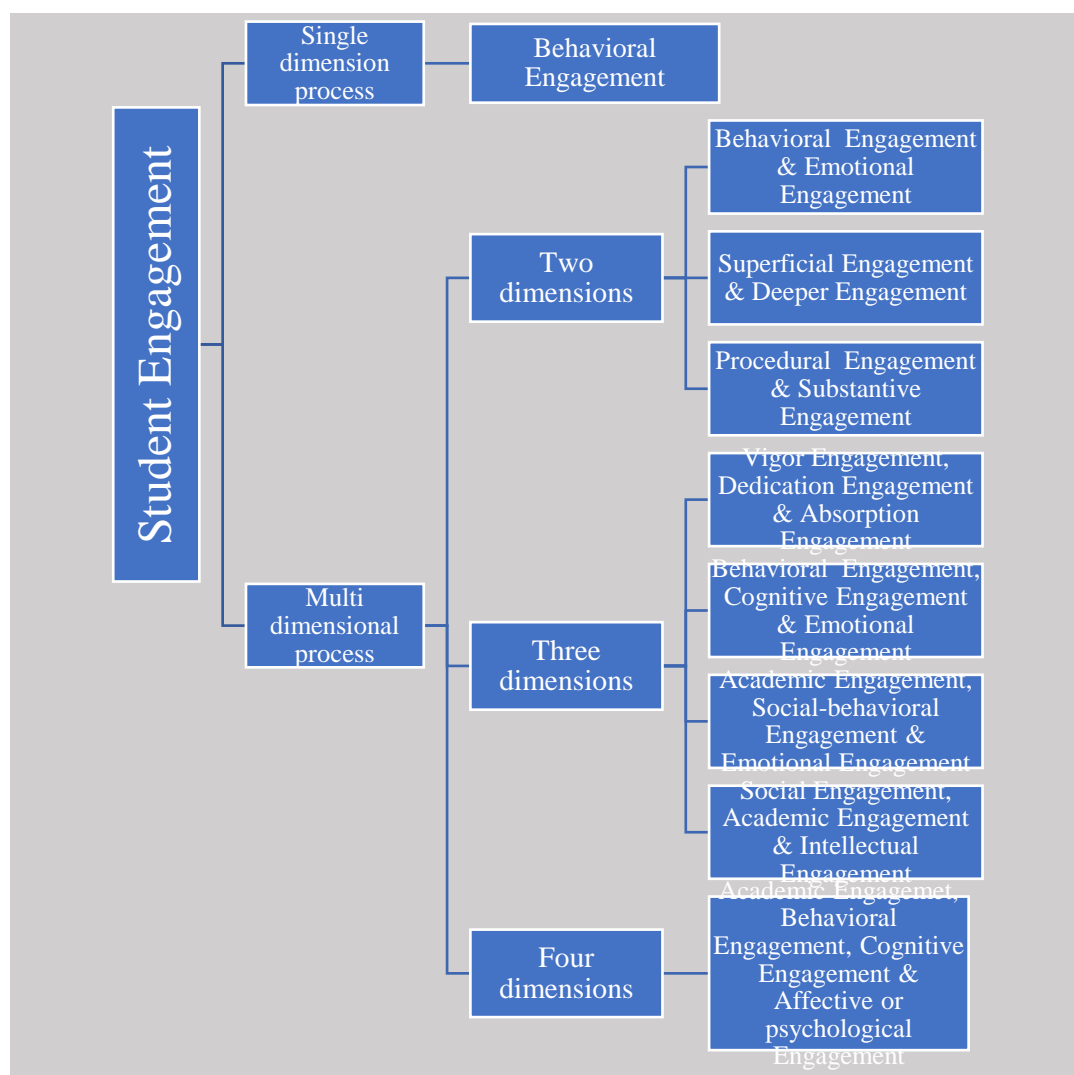


Figure 1: Student Engagement Categories

### 2.3 Blackboard

Blackboard is a learning management system (LMS), that has effective implications in the education settings. Blackboard with its broader use can be used as an information repository to deliver the course content and additional learning materials. In addition, the Blackboard can be used as a communication method between instructors and students via discussion boards, emails, announcements, and podcasts. Attitude and acceptance of blackboard was found to be related to users' efficiency [46]. Blackboard is an application for online teaching, learning, community building, and knowledge sharing as defined by blackboard help and it is one of the popular LMS used in higher education institutions. The blackboard software uses web tools to create secure online training for users, and it includes a collaborative server that allows users to create text-based environments allows users to interact with each other [47]. The Blackboard as a LMS is broadly adopted by many universities in the UAE to deliver the content of several courses. According to [48], in fall 2002, the number of courses offered via Blackboard increased from less than 200 to 600 courses in the following semester spring 2003 and reached 1000 by 2010. Furthermore, in fall 2002, the active users' number leaped from 1200 to be about 8000 in 2010. Today, Blackboard as a LMS has been adopted by most of the higher education institutions in the UAE to facilitate virtual learning and make it accessible for learners [49].

Before the transition to online learning, blackboard System was used at many universities in the UAE by using fewer features of the system capabilities, as the need wasn't essential and face-to-face education gives the instructor variety in teaching methods, interaction, and evaluation of the students. After the transition to online learning the need become vital and instructors begun to use more features added to the assignment tool and the grade center which was already used before as: Real-time video conferencing tool, tests and surveys, mobile web conferencing, browser-based web conferencing, simple, fast file sharing, virtual whiteboard to interact with others, session recordings and many other features that become the first communication channel with the students.

## 2.4 Research Questions

To address the purpose of this study, the following research questions were proposed.

- (1) What is the attitude towards the e – learning among College of Engineering students as measured by Liaw’s model?
- (2) What is the students’ level of experience in using the e – learning system among College of Engineering students in the UAE?
- (3) What are the predictor factors that could influence students’ e – learning satisfaction among Engineering students?

## 3. Methods

### 3.1 Sample

The sample of this research study consists of 268 undergraduate students distributed as (n= 164 (61.2%) females; 104 (38.8%) males) enrolled in the Colleges of Engineering in different higher education institutions in the UAE and all of them using the Blackboard as a Learning Management System (LMS). The sample was aged from 18 – 22 as represented in (Table 1). Participants’ level of education varied from undergraduate freshman (first year) to graduate student (See table 2). The participants are a representative sample of a multicultural students as shown in (Table 3). The E-learning experience was determined by participants response to a 7-point Likert scale (ranging from 1 which means “no experience” to 7 which means “well experienced”).

Table 1: Participants’ distribution by age

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 18.00	69	25.7	25.7	25.7
19.00	97	36.2	36.2	61.9
20.00	73	27.2	27.2	89.2
21.00	22	8.2	8.2	97.4
22.00	7	2.6	2.6	100.0
Total	268	100.0	100.0	

Table 2: The sample distribution by education level

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Undergraduate Freshman (first year)	74	27.6	27.6	27.6
Undergraduate Sophomore (second year)	125	46.6	46.6	74.3
Undergraduate Junior (third year)	57	21.3	21.3	95.5
Undergraduate Senior (fourth year)	12	4.5	4.5	100.0
Total	268	100.0	100.0	

Table 3: The sample distribution by nationality

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid UAE	115	42.9	42.9	42.9
Iraq	5	1.9	1.9	44.8
Egypt	47	17.5	17.5	62.3
Syria	12	4.5	4.5	66.8
Jordan	42	15.7	15.7	82.5
KSA	15	5.6	5.6	88.1
Algeria	1	.4	.4	88.4
USA	13	4.9	4.9	93.3
India	9	3.4	3.4	96.6
Pakistan	6	2.2	2.2	98.9
Sudan	3	1.1	1.1	100.0
Total	268	100.0	100.0	

### 3.2 Instrumentation

Liaw's model consists of 26 questions distributed over 8 domains including *Perceived self-efficacy* (3 questions), *Perceived satisfaction* (4 questions), *Perceived usefulness* (3 questions), *Behavioral intention* (3 questions), *e-learning system quality* (4 questions), *Interactive learning activities* (3 questions), *E-learning effectiveness* (3 questions), and *Multimedia instruction* (3 questions). Liaw's model is a 7 – point Likert scale ranged from 1 = *strongly disagree* to 7= *strongly agree*. The high scores in each individual domain represents positive perception and positive attitude towards the e – learning system. The positive attitude is determined by a total score higher than 4. In addition, students' level of experience in e – learning is measured by a 7 – point Likert scale with 1 indicates “no experience” and 7 indicates “well experienced”.

### 3.3 Instrument Reliability and Validity

According to the research study of [8], in this model of e-learning effectiveness, students' attitudes showed a high internal consistency of reliability, Cronbach's  $\alpha = 0.97$  for the model entirely and items' coefficients ranged from 0.57 to 0.80. which indicates adequate reliability of the scales. For this study, Cronbach's  $\alpha$  was computed to measure the internal reliability, it showed high reliability ranging from .651 to .887 for the scale domains and the reliability for the entire scale  $\alpha = .921$ . Achieving  $\alpha$  values that exceed 0.7, indicates adequate reliability [50] (See Table 5). For the instrument validity, the scale was discussed with panel of experts in the UAE to ensure its validity for the students at the College of Engineering in the U

Table 4: The internal consistency of the scale

Item	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Perceived self-efficacy	.887	.889	3
Perceived satisfaction	.851	.850	4
Perceived usefulness	.782	.786	3
Behavioral intention	.846	.848	3
e-learning system quality	.767	.771	4
Interactive learning activities	.651	.646	3
E-learning effectiveness	.758	.763	3
Multimedia instruction	.780	.782	3
Entire scale	.921	.925	26

N=268

### 3.4 Data Collection

The Spring of 2021 is the beginning of the second year since the transition to e – learning after the outbreak of COVID – 19 Pandemic, so it was an appropriate time to collect data to measure students' attitude towards e – learning after one full year of using it. Data collection process continued for 5 weeks. Liaw's Questionnaire was modeled on *Google forms* with a full description of the study objective and nature, furthermore, the consent form was included. Researchers emailed many instructors and professors from different colleges of Engineering in the UAE asking for permission to visit their e – learning classes to present the study objectives and invite students to participate in the study. After receiving permission, the researchers visited many virtual classes and explained to the students the purpose of the study and the procedure to answer the questionnaire. The researchers posted the study link with guidelines and were available during administering the questionnaire to reply to any emerged

concerns or questions. Data collection was an anonymous process, and all data was transferred to SPSS version 22.0 for analysis and conclusion.

### 3.5 The Neutrosophic DEMATEL Method

In 1974, Gabus and Fontela were the ones who first presented the DEMATEL technique. The method's purpose is to illustrate the interdependencies of the components that are being examined in relation to one another. Over the course of the years, it has been mostly used in integrated decision making techniques for the purpose of determining whether or not there is a reliance [51, 52].

Step 1: Construct the linguistic influence matrix

Step 2: Convert the opinions of experts into a neutrosophic number

Step 3: Combine the matrices into one matrix

Step 4: Normalize the matrix by using:

$$N = n \left( \frac{1}{\max \sum_{i=1}^n |a_{ij}|}, \frac{1}{\max \sum_{i=1}^n |a_{ij}|} \right) \quad (1)$$

$$C = N \cdot A \quad (2)$$

Step 5: Compute the total relation matrix R

$$R = C \cdot (I - M)^{-1} \quad (3)$$

Step 6: Compute the values of D and R

Step 7: Compute the D+R value

Step 8: Normalize the D+R values

## 4. Data Analysis and Findings

To answer **RQ 1** and find out the students' attitude towards the e – learning (Blackboard), descriptive analysis revealed that high positive attitude across all the domains of Liaw's model. For *Self – efficacy* ( $M= 5.7500$ ,  $SD = 1.02573$ ), *perceived satisfaction*, ( $M= 5.3750$ ,  $SD = 1.08671$ ), *Perceived usefulness* ( $M= 5.1978$ ,  $SD = 1.20352$ ), *Behavioral intention* ( $M= 5.4279$ ,  $SD = 1.10318$ ), *System quality* ( $M= 5.1213$ ,  $SD = 1.09508$ ), *Interactive learning activities* ( $M= 4.9590$ ,  $SD = 1.20495$ ), *E – learning effectiveness* ( $M= 5.0274$ ,  $SD = 1.33243$ ), *Multimedia instruction* ( $M= 4.9801$ ,  $SD = 1.21563$ ).

For **RQ 2**, descriptive analysis revealed that students in the College of Engineering showed a high level of experience, ( $M= 5.974$ ,  $SD = 1.00712$ ) in a 7 – point Likert scale, so they were found to be well – experienced in Learning Management System, e – learning (Blackboard), which could indicate the high technical skills and reflect perceived usefulness and satisfaction about the LMS (See Table 5 & Figure 1). These findings of students' level of experience is confirmed by Liaw's scale for students' *Self – efficacy* ( $M= 5.7500$ ,  $SD = 1.02573$ ),

Table 5: The sample distribution by experience in Learning Management System (Blackboard)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor experience	2	.7	.7	.7
	Fair experience	2	.7	.7	1.5
	Good experience	18	6.7	6.7	8.2
	High experience	53	19.8	19.8	28.0
	Very good experience	97	36.2	36.2	64.2
	Well experience	96	35.8	35.8	100.0
	Total	268	100.0	100.0	

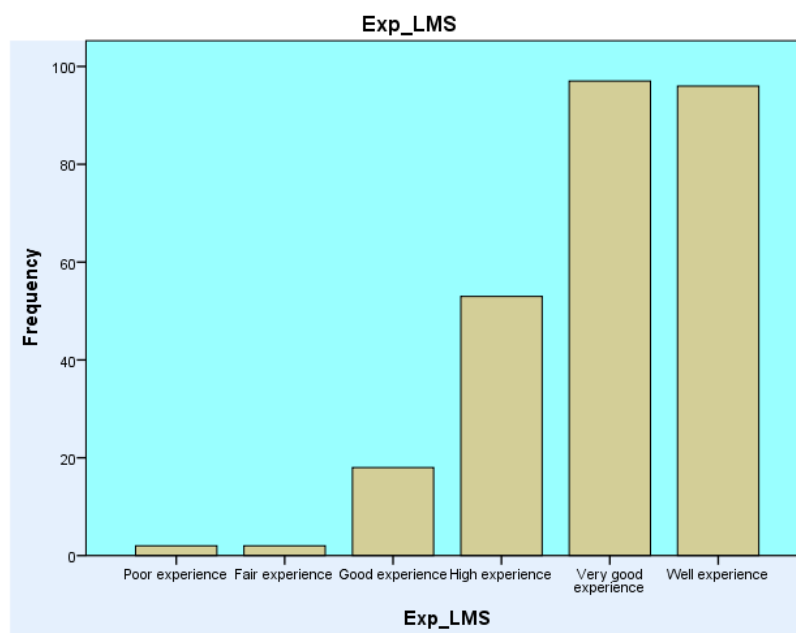


Figure 2: The students' Experience in the E – learning/Learning Management System (Blackboard)

To answer **RQ 3**, the stepwise multiple regression method was chosen to indicate **only “significant” predictors** in the regression model. The stepwise analysis was performed to check the effect of multimedia instruction, self – efficacy, interactive learning activities, and e – learning System quality on students' perceived satisfaction. The results demonstrated that three variables are significant predictors, which are multimedia instruction, self – efficacy, and e – learning System quality. A significant regression equation was found for model 1 ( $F(1, 266) = 197.800, p < .000$ ), with an  $R^2$  of .426. for model 2 ( $F(2, 265) = 158.028, p < .000$ ), with an  $R^2$  of .544. for model 3 ( $F(3, 264) = 108.721, p < .000$ ), with an  $R^2$  of .553.

$$(4) Y' = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \beta_3 * x_3 + \epsilon$$

$$Satisfaction = 0.343 + 0.454 * System\ quality + 0.393 * Self - efficacy + 0.089 * multimedia\ instruction.$$

All independent variables are significant predictors of perceived satisfaction. Table 6 shows that system quality and self – efficacy are highly correlated with the perceived satisfaction, however, the interactive learning activities and multimedia are weakly correlated with the dependent variable. Based on the stepwise results, multicollinearity is not a problem as  $VIF < 5$  (See Table 7). Figure 1 represents the scatterplot with predicted values (perceived satisfaction) on the x-axis and residuals on the y-axis. From figure 1 & figure 2 (Q – Q plot), there is no violations of the independence, homoscedasticity, and linearity assumption.

Table 6: The correlation between the independent variables and the dependent variable \_RQ 2

		PerceivedSati	SystemQualit	InteractiveAc	Multimedia_	Self_efficacy
		sfaction_Tota	y_Total	tivity_Total	Total	Total
		1				
Pearson Correlation	PerceivedSatisfaction_Tot	1.000	.653	.353	.333	.594
	SystemQuality_Tot	.653	1.000	.467	.328	.438
	InteractiveActivity_Tot	.353	.467	1.000	.413	.285
	Multimedia_Tot	.333	.328	.413	1.000	.223
	Self_efficacyTotal	.594	.438	.285	.223	1.000
Sig. (1-tailed)	PerceivedSatisfaction_Tot	.	.000	.000	.000	.000
	SystemQuality_Tot	.000	.	.000	.000	.000
	InteractiveActivity_Tot	.000	.000	.	.000	.000
	Multimedia_Tot	.000	.000	.000	.	.000
	Self_efficacyTotal	.000	.000	.000	.000	.

N= 268

Table 7: The multicollinearity between the independent variables

Model		Beta In	t	Sig.	Collinearity Statistics			Minimum Tolerance
					Partial Correlation	Tolerance	VIF	
1	InteractiveActivity_	.062 <sup>b</sup>	1.184	.237	.073	.782	1.278	.782
	Multimedia_	.132 <sup>b</sup>	2.727	.007	.165	.892	1.121	.892
	Self_efficacy	.381 <sup>b</sup>	8.261	.000	.453	.808	1.237	.808
2	InteractiveActivity	.023 <sup>c</sup>	.485	.628	.030	.774	1.292	.681
	Multimedia	.099 <sup>c</sup>	2.270	.024	.138	.884	1.131	.752
3	InteractiveActivity	-.010 <sup>d</sup>	-.210	.834	-.013	.703	1.423	.669

a. Dependent Variable: PerceivedSatisfaction\_Total

b. Predictors in the Model: (Constant), SystemQuality\_Total

c. Predictors in the Model: (Constant), SystemQuality\_Total, Self\_efficacyTotal

d. Predictors in the Model: (Constant), SystemQuality\_Total, Self\_efficacyTotal, Multimedia\_Total

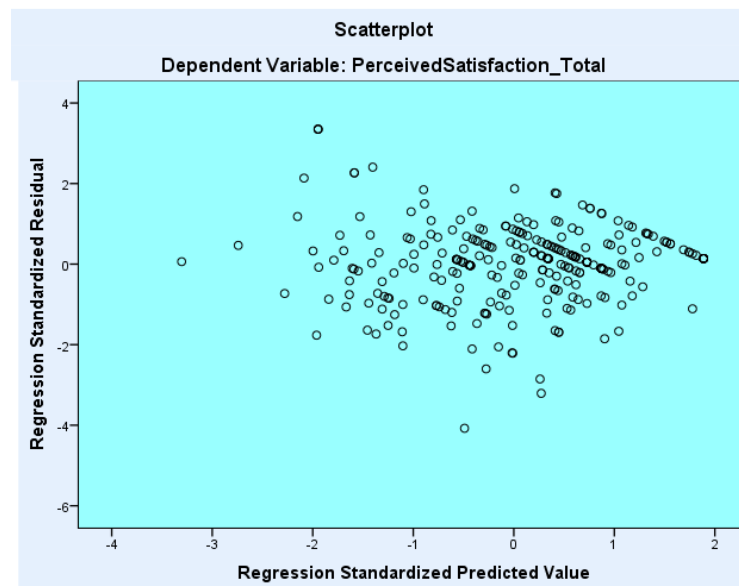


Figure 3: The relationship between Predictors and Satisfaction

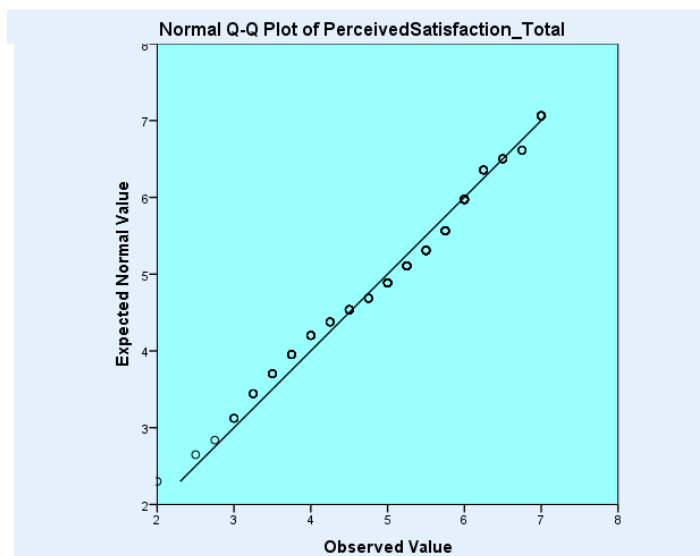


Figure 4: Normal Q – Q Plot

**4.1 Neutrosophic DEMATEL Method**

The data set contains the vague information. So, the neutrosophic sets used to overcome this issue. The neutrosophic integrated with the DEMATEL method to show the effects of criteria to each other. First the build the pairwise comparison matrix from the dataset. Then normalize the pairwise using Eqs. (1,2). The normalization matrix shown in table 8. Then compute the total relation matrix from the normalization matrix using Eq. (3). The total relation matrix is shown in table 9. Then compute the value of R and D. Then compute the D+R and D-R values. The values of D+R and D-R are show in table 10. Figure 5 shows the casual diagram form the D+R and D-R values. Figure 6 shows the scatter plot of D+R values. From these figures the criterion 2 has he most effects and criterion 3 has the least effects in the all criteria.

Table 8: The normalization matrix.

	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>
S <sub>1</sub>	28.57576	17.14545	11.4303	17.14545	25.71818	18.86	28.29	3.429091
S <sub>2</sub>	47.62626	28.57576	14.28788	11.14455	19.43152	27.43273	20.00303	3.143333
S <sub>3</sub>	71.43939	57.15152	28.57576	8.572727	6.572424	21.43182	25.71818	9.43
S <sub>4</sub>	47.62626	73.27117	95.25253	28.57576	5.715152	24.28939	19.71727	12.57333
S <sub>5</sub>	31.75084	42.02317	124.2424	142.8788	28.57576	8.572727	9.43	15.71667
S <sub>6</sub>	43.2966	29.76641	38.10101	33.61854	95.25253	28.57576	6.286667	18.86
S <sub>7</sub>	28.8644	40.82251	31.75084	41.41414	86.5932	129.8898	28.57576	18.86
S <sub>8</sub>	238.1313	259.7796	86.5932	64.9449	51.95592	43.2966	43.2966	28.57576

Table 9: The total relation matrix.

	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>
S <sub>1</sub>	-0.97508	-0.03758	-0.01222	0.006538	-0.00255	-0.0043	0.005095	0.003293
S <sub>2</sub>	-0.0174	-0.97679	0.02126	-0.00542	0.003789	0.005668	-0.0033	-0.00906
S <sub>3</sub>	0.008179	-0.02497	-0.98725	-0.01636	0.001296	-0.00336	0.004543	0.003382
S <sub>4</sub>	-0.00399	0.005709	-0.00063	-0.98799	-0.00868	0.005363	-0.00253	-0.00241
S <sub>5</sub>	-0.0108	-0.01356	0.028071	-0.00509	-0.99592	-0.00918	0.003337	-0.00272
S <sub>6</sub>	0.016117	-0.01765	0.001627	-0.00026	-0.00017	-0.99399	-0.00818	0.001149
S <sub>7</sub>	-0.05202	0.032262	-0.0117	-0.00287	0.002351	0.005523	-0.99885	0.002197
S <sub>8</sub>	0.009138	0.173427	-0.1704	0.032203	-0.00841	-0.01913	-0.01642	-0.98447

Table 10: The values of R and D

	R+D	R-D
S <sub>1</sub>	-2.04265	0.009048
S <sub>2</sub>	-1.84041	-0.12211
S <sub>3</sub>	-2.14577	0.116688
S <sub>4</sub>	-1.97439	-0.01591
S <sub>5</sub>	-2.01415	0.002447

$S_6$	-2.01476	0.01205
$S_7$	-2.03942	-0.00679
$S_8$	-1.9727	0.004572

(5)

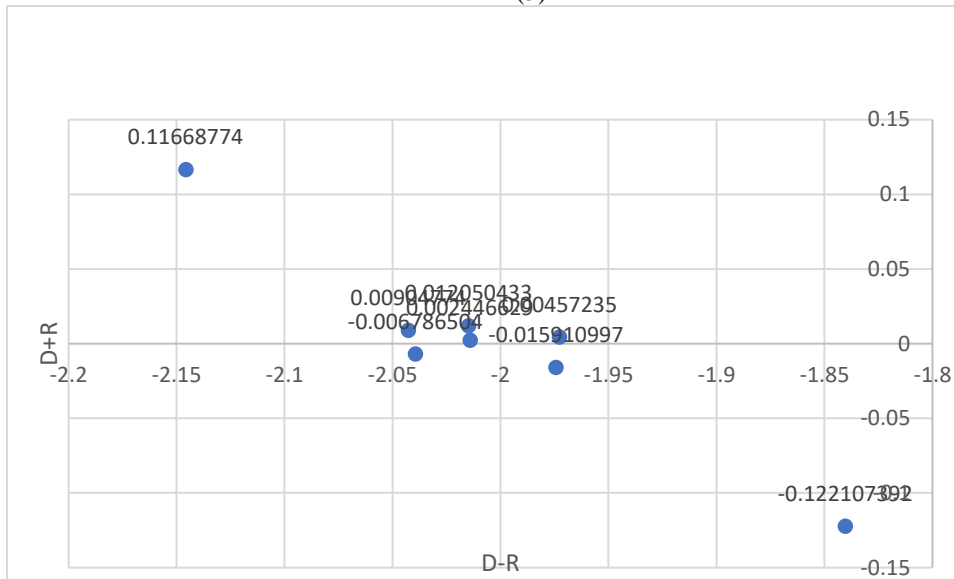


Figure 5: The causal diagram

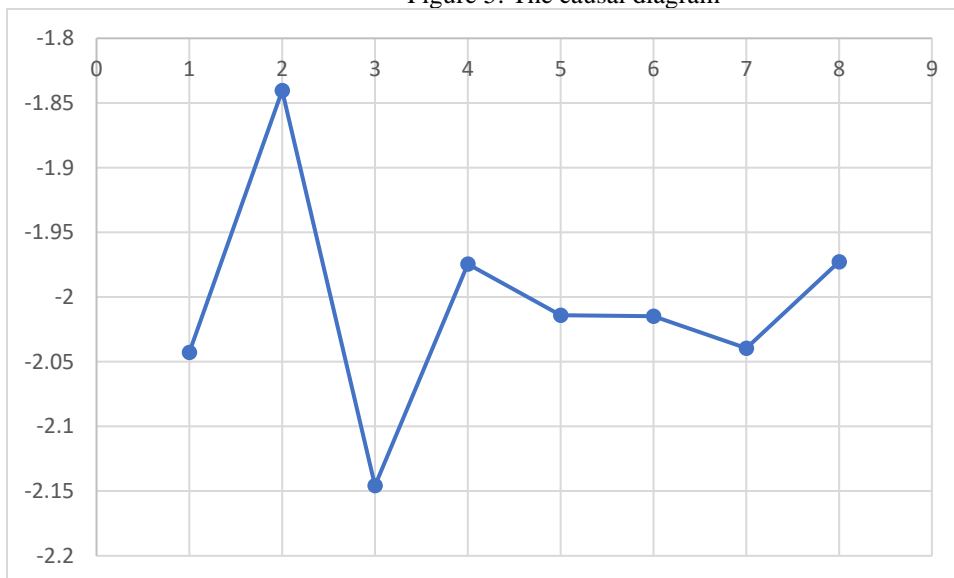


Figure 6: The scatter plot of data.

### 5. Discussion

This research study was conducted to investigate the students’ attitudes, perception of e – learning and find out the significant predictors of students’ perceived satisfaction about the e – learning system/Blackboard. Findings showed that higher education students in the College of Engineering have high positive attitudes towards the e – learning system and possess high e – self-efficacy. These findings could be interpreted as students’ high technical abilities increase their attitudes towards the e – learning. Moreover, Engineering students have high e – readiness to accept full transition to online learning. These results are expected as Engineering students are identified with their high technical abilities and these abilities are well developed as they progress in studying Engineering major. These findings agree with [24, 8] who revealed that college students’ positive attitude towards e – learning. These findings could be integrated to Engineering education effectively such as offering hybrid courses even after reverting to face – to – face mode of learning. The findings of the predictors of students’ satisfaction demonstrated that three out of four variables are significant predictors, which are multimedia instruction, self – efficacy, and e – learning System quality. This outcome is expected because students who have high self – efficacy will deal with the e – learning system effectively and professionally which increases their satisfaction. System learning quality is expected to predict students’ satisfaction as the system is well – designed with good functionality, students are expected to be satisfied about it, which indicates

that higher education institutions in the UAE adopts functional and advanced LMS. For students' satisfaction about the multimedia instruction, it can be interpreted as undergraduate Engineering students with age ranged from 18 – 24 which means they are digital native [53] who are expected to show high satisfaction about e – learning system that include more multimedia content. These results are consistent with the findings of [25], who found these as predictor factors of students' satisfaction about e – learning. The implementation could be found in maintain the quality of the e – system, increasing the multimedia instructions to raise students' satisfaction which could increase their academic achievement. The fourth variable, which is interactive learning activities was found not a predictor of students' satisfaction about e – learning, which could be explained as the transition to online learning is a new approach for Engineering students in the UAE, which could require some time for students to build familiarity with the e – class activities or this could reflect the less preference for online engagement. This result agrees with [54] who revealed that students show limited engagement in online activity comparing to their engagement in on – campus learning. Limitations of this study underlies the stepwise regression as there is several potential predictors here in this study, however, there is insufficient data to estimate coefficients meaningfully.

## 6. Conclusion

This quantitative research study was conducted to determine students' attitude towards e – learning in the College of Engineering in the UAE. Engineering students in the UAE were identified with high positive attitude towards e – learning/ Blackboard, which reflected their positive perception of their LMS/Blackboard. Moreover, Engineering students in the UAE were found to possess advanced e – self-efficacy, which refer to their ability to deal with e – learning system professionally. Multimedia instruction, self – efficacy, and e – learning System quality were shown as significant predictors of students' satisfaction about the e – learning system. In conclusion, College of Engineering in the UAE adopt advanced e – learning system and present well designed multimedia instructions. The neutrosophic sets was used in this paper to overcome the vague data. The neutrosophic sets integrated with the MCDM methodology. The concept of MCDM used due to this paper contains many criteria. The neutrosophic combined with the DEMATEL method to show the effects of criteria.

## 7. Recommendations

The findings of this research study showed that students in the College of Engineering in the UAE have positive perceived satisfaction about the e-learning system/Blackboard with three predictors that can interpret students' satisfaction: self-efficacy, multimedia instructions, and e-system quality. These findings could be integrated into instructional design and curriculum preparation such as designing parallel forms curriculum i.e., the traditional instructions for face-to-face and other instructions to be delivered online and make both instructions available for students' choice. Furthermore, as students show positive attitude towards multimedia instructions, this could be implemented in assessment; integrating multimedia assessment that is based on assessing students learning outcomes by using multimedia to make the learning process more consistent. Design course assessment to promote students' e-self-efficacy, which could be implemented by including advanced software such as *simulations* or *tinkercad* to help students imagine and create more designs related to the Engineering field. For the findings of interactive class activities that was not a predictor of students' satisfaction, it could be boosted by linking the interactive learning activities to the integrated multimedia, which could enhance students' preference towards learning activities. Moreover, link the learning activities to a direct assessment to encourage students' participation. **Future research** should focus on considering the influence of the rest of Liaw's (2008), the 8 domains such as perceived usefulness, behavioral intention, and e – learning effectiveness and how do these domains influence students' academic success and their preference to continue in online Engineering program over revert to face-to-face mode.

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## References

- [1] George P., Papachristou N., Belisario J., Wang W., Wark P., Cotic Z., Rasmussen K., Sluiter R., Riboli Sasso E., Tudor Car L., Musulanov E., Molina J., Heng B., Zhang Y., Wheeler E., Al Shorbaji N., Majeed A., Car J., Online eLearning for undergraduates in health professions: A systematic review of the impact on knowledge, skills, attitudes, and satisfaction. *J Glob Health*, 4(1) (2014). DOI: [10.7189/jogh.04.010406](https://doi.org/10.7189/jogh.04.010406)
- [2] Allen, I. E., & Seaman, J., *Going the distance: Online education in the United States, 2011*. Sloan Consortium, Newburyport, MA.(2011). <https://files.eric.ed.gov/fulltext/ED529948.pdf>
- [3] Karabulut-Ilgu, A., Jaramillo Cherez, N., & Jahren, C. T., A systematic review of research on the

flipped learning method in engineering education. *British Journal of Educational Technology*, 49(3), 398-411 (2018). <https://doi.org/10.1111/bjet.12548>

[4] Violante, M. G., & Vezzetti, E., Implementing a new approach for the design of an e-learning platform in engineering education. *Computer Applications in Engineering Education*, 22(4), 708-727 (2014). <https://doi.org/10.1002/cae.21564>

[5] Chou, P. N., The relationship between engineering students self-directed learning abilities and online learning performances: A pilot study. *Contemporary Issues in Education Research (CIER)*, 5(1), 33-38 (2012). <https://doi.org/10.19030/cier.v5i1.6784>

[6] Bourne, J., Harris, D., & Mayadas, F., Online engineering education: Learning anywhere, anytime. *Journal of Engineering Education*, 94(1), 131-146, (2005) <https://doi.org/10.1002/j.2168-9830.2005.tb00834.x>

[7] Liaw, S. S., & Huang, H. M., Developing a collaborative e-learning system based on users' perceptions. *Lecture Notes in Computer Science*, 4402, 751-759 (2007). [https://link.springer.com/chapter/10.1007/978-3-540-72863-4\\_76](https://link.springer.com/chapter/10.1007/978-3-540-72863-4_76)

[8] Liaw, S. S., Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system. *Computers & education*, 51(2), 864-873, (2008). <https://doi.org/10.1016/j.compedu.2007.09.005>

[9] Liaw, S. S., Huang, H. M., & Chen, G. D., An activity-theoretical approach to investigate learners' factors toward e-learning systems. *Computers in Human Behavior*, 23, 1906-1920 (2007). <https://doi.org/10.1016/j.chb.2006.02.002>

[10] Northrup, P., A framework for designing interactivity into Web-based instruction. *Educational Technology*, 41(2), 31-39 (2001). <https://www.jstor.org/stable/44428657>

[11] Salamai, A. A. An integrated neutrosophic SWARA and VIKOR method for ranking risks of green supply chain. *Neutrosophic Sets and Systems* **41**, 113-12 (2021).

[12] Bolturk, E. & Kahraman, C. A novel interval-valued neutrosophic AHP with cosine similarity measure. *Soft Computing* **22**, 4941-4958 (2018).

[13] Zhang, H., Wang, J. & Chen, X. An outranking approach for multi-criteria decision-making problems with interval-valued neutrosophic sets. *Neural Computing and Applications* **27**, 615-627 (2016).

[14] Gül, S. Spherical fuzzy extension of DEMATEL (SF-DEMATEL). *International Journal of Intelligent Systems* **35**, 1329-1353 (2020).

[15] Veeramani, C., Venugopal, R. & Edalatpanah, S. A. Neutrosophic DEMATEL approach for financial ratio performance evaluation of the NASDAQ Exchange. *Neutrosophic Sets and Systems* **51**, 766-782 (2022).

[16] Tian, L. & Gu, H. Using the Neutrosophic DEMATEL Method to Determine the Effect of Internet Finance and Big Data Risk Control Monitoring. *Wireless Communications and Mobile Computing* **2022**, (2022).

[17] Salamai, A. A. Neutrosophic-based machine learning context for the trustworthiness of devices in the internet of things. *Journal of Neutrosophic and Fuzzy Systems* **1**, 59 (2023).

[18] Tripathi, S. & Gupta, M. Identification of challenges and their solution for smart supply chains in Industry 4.0 scenario: a neutrosophic DEMATEL approach. *International Journal of Logistics Systems and Management* **40**, 70-94 (2021).

[19] Sundareswaran, R. *et al.* Assessment of structural cracks in buildings using single-valued neutrosophic DEMATEL model. *Materials Today: Proceedings* **65**, 1078-1085 (2022).

[20] Kilic, H. S. & Yalcin, A. S. Comparison of municipalities considering environmental sustainability via neutrosophic DEMATEL based TOPSIS. *Socio-Economic Planning Sciences* **75**, 100827 (2021).

- [21] Kilic, H. S., Yurdaer, P. & Aglan, C. A leanness assessment methodology based on neutrosophic DEMATEL. *Journal of Manufacturing Systems* **59**, 320–344 (2021).
- [22] McAndrew, M. & Johnston, A. E., The Role of social media in Dental education. *Journal of Dental Education*. 76. 1474-81(2012). 10.1002/j.0022-0337.2012.76.11.tb05409.x.  
<https://doi.org/10.1002/j.0022-0337.2012.76.11.tb05409.x>
- [23] Linjawi, A., Walmsley, A., & Hill, K., *Online discussion boards in dental education: potential and challenges*. *European Journal of Dental Education*, 16(1): p. e3-e9 (2012).  
<https://doi.org/10.1111/j.1600-0579.2010.00662.x>
- [24] Smart, K. L., & Cappel, J. J., Students' perceptions of online learning: A comparative study. *Journal of Information Technology Education: Research*, 5(1), 201-219 (2006).  
[file:///C:/Users/nahla/Downloads/article\\_111541%20\(1\).pdf](file:///C:/Users/nahla/Downloads/article_111541%20(1).pdf)
- [25] Paechter, M., Maier, B., & Macher, D., Students' expectations of, and experiences in e-learning: Their relation to learning achievements and course satisfaction. *Computers & education*, 54(1), 222-229 (2010).  
<https://doi.org/10.1016/j.compedu.2009.08.005>
- [26] Linjawi, A.I., & Alfadda, L.S., Students' perception, attitudes, and readiness toward online learning in dental education in Saudi Arabia: *a cohort study*. *Advances in Medical Education and Practice*, 9, p. 855. (2018).
- [27] Bali, S. & M. Liu, M., *Students' perceptions toward online learning and face-to-face learning courses*. *Journal of Physics: Conference Series*, 1108 (1), p. 012094. (2018). IOP Publishing. doi :10.1088/1742-6596/1108/1/012094
- [28] Fortune, M.F., Spielman, M., & Pangelinan, D. T., Students' perceptions of online or face-to-face learning and social media in hospitality, recreation and tourism. *MERLOT Journal of Online Learning and Teaching*, 7(1) (2011). [https://jolt.merlot.org/vol7no1/fortune\\_0311.pdf](https://jolt.merlot.org/vol7no1/fortune_0311.pdf)
- [29] Fidalgo, P., Thormann, J., Kulyk, O., & Lencastre, A. J., Students' perceptions on distance education: A multinational study. *International Journal of Educational Technology in Higher Education*, 17, 18. (2020).  
<https://doi.org/10.1186/s41239-020-00194-2>
- [30] Elbaum, B., McIntyre, C. & Smith, A., *Essential Elements: Prepare, design, and teach your online course*. Atwood Publishing. (2020). <https://eric.ed.gov/?id=ED501904>
- [31] Dobbs, R.R., Waid, C.A., & Del Carmen, A., Students' perception of online courses: The effect of online course experience. *Quarterly Review of Distance Education*, 10(1), p. 9 (2009).  
<https://www.proquest.com/docview/1933128185/fulltextPDF/BAC29DCA56D24484PQ/1?accountid=16946>
- [32] Hashim, H. & Tasir, Z., *E-learning readiness: A literature review*. in *2014 International Conference on Teaching and Learning in Computing and Engineering*, IEEE(2014). <https://doi.org/10.1109/LaTiCE.2014.58>
- [33] De Paepe, L., Zhu, C., & Depryck, K., Online Dutch L2 learning in adult education: Educators' and providers' viewpoints on needs, advantages and disadvantages. *Open Learning: The Journal of Open, Distance and e-Learning*, 33(1), p. 18 – 33 (2018). <https://doi.org/10.1080/02680513.2017.1414586>
- [34] Wu, F. & Fang, Y. Multilevel Evaluation of Teaching Quality in Higher Education Using Single-Valued Neutrosophic Set. *Mobile Information Systems* **2022**, (2022).
- [35] Banday, M.T., *E-learning in Web 2.0 world: A case study*. In *2012 IEEE International Conference on Engineering Education: Innovative Practices and Future Trends (AICERA)* (2018)..
- [36] Pitchian, A. & Churchill, D., *E-Learning design for engineering education*. in *Fourth Asia-Pacific Conference on Problem-Based Learning, Hatyai, Songkora, Thailand*, (2002).

- [37] Sarangi, S.K., *Continuing Engineering Education through E-learning: A strategy for development*. International Association for Continuing Engineering Education News Letter, (2004).
- [38] Zhai, G., Wang, Y., & Liu, L., Design of electrical online laboratory and E-learning. *IERI Procedia*, 2, 325-330, (2012). <https://doi.org/10.1016/j.ieri.2012.06.096>
- [39] Peterson, G. D., & Feisel, L. D., e-Learning: The challenge for engineering education, (2002). <https://dc.engconfintl.org/cgi/viewcontent.cgi?article=1026&context=etechnologies>
- [40] ABET., *Strategic plan, accreditation board for engineering and technology*. inc.,(ABET), 1.(1997).
- [41] Gustavsson, I., Nilsson, K., Zackrisson, J., Garcia-Zubia, J., Hernandez, U., Nafalski, A., Nedic, Z., Göl, Ö., Machotka, J., Pettersson, M., Lagö, T., & Håkansson, L., On Objectives of instructional laboratories, individual assessment, and use of collaborative remote laboratories (HTML). *IEEE Transactions on Learning Technologies*, 2, 263-274, (2009). DOI:[10.1109/TLT.2009.42](https://doi.org/10.1109/TLT.2009.42)
- [42] Khogali, H., *The Effect of COVID-19 CORONA VIRUS on Sustainable Teaching and Learning in Architecture Engineering*. *Modern Applied Science*, 14, p. 50, (2020).
- [43] Hu, M., Li, H., Deng, W., & Guan, H., Student engagement: one of the necessary conditions for online learning. In *2016 International Conference on Educational Innovation through Technology (EITT)* (pp. 122-126). IEEE(2016). <https://doi.org/10.1109/EITT.2016.31>
- [44] Kim, C., Park, S. W., Cozart, J., & Lee, H., From motivation to engagement: The role of effort regulation of virtual high school students in mathematics courses. *Journal of Educational Technology & Society*, 18(4), 261-272, (2015).
- [45] Hu, M., & Li, H., Student engagement in online learning: A review. In *2017 International Symposium on Educational Technology (ISET)* (pp. 39-43). IEEE (2017, June).<https://doi.org/10.1109/ISET.2017.17>
- [46] Mioduser, D., Nachmias, R., Oren, A. and Lahav, O., Web-Based Learning Environments (WBLE): Current Implementations and Evolving Trends. *Journal of Network and Computer Applications*, 22, 233-247, (1999). <https://doi.org/10.1006/jnca.1999.0093>
- [47] Patterson, T., *Blackboard learn administration*. Packt Publishing Ltd (2013).
- [48] Ati, M., Guessoum, N., Demiray, L. V. U., Sahin, M. C., Kurubacak, G., Lounaskorpi, P. T., & Rao, S. R., E-learning in the United Arab Emirates. *E-learning practices. Cases on challenges facing e-learning and national development: Institutional studies and practices*, 2, 1009-1028, (2010).
- [49] Education UAE (March 2020). Blackboard makes its virtual classroom solution accessible to institutionsthrough new easy to use self-service portal. Retrieved from: <https://www.education-uae.com/BLACKBOARD-MAKES-ITS-VIRTUAL-CLASSROOM-SOLUTION-ACCESSIBLE-TO-INSTITUTIONS-THROUGH-NEW-EASY-TO-USE-SELF-SERVICE-PORTAL/>
- [50] Nunnally, J.C., *Psychometric Theory*. New York: McGraw-Hill, (1978).
- [51] Nabeeh, N. A. A hybrid neutrosophic approach of DEMATEL with AR-DEA in technology selection. *Neutrosophic Sets and Systems* **31**, 17–30 (2020).
- [52] Al-Quran, A., Hashim, H. & Abdullah, L. A hybrid approach of interval neutrosophic vague sets and DEMATEL with new linguistic variable. *Symmetry* **12**, 275 (2020).
- [53] Prensky, M., “Digital natives, digital immigrants”, *On the Horizon*, 9(5), 1-6, October. MCB University Press. (2001) <https://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf>

[54] Robinson, C. C., & Hullinger, H., New benchmarks in higher education: Student engagement in online learning. *Journal of Education for Business*, 84(2), 101-109, (2008).  
<https://doi.org/10.3200/JOEB.84.2.101-109>