Analyzing Digital Education using Neutrosophic Sets

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Abstract

Digital learning is a broad umbrella of any form of learning incorporating novel digital technology aspects in teaching and assessment to facilitate learning and engage students. Most education settings have moved from face–to–face to e-learning platforms worldwide ever since the beginning of the COVID-19 pandemic. Assessment of the efficiency of digital learning is essential, and assessment criteria may take several forms. Digital learning effectiveness assessment has received a significant amount of attention and work; nevertheless, a generalized quantitative evaluation model that considers the inter-affected link among criteria and the uncertainty of personal perception simultaneously is still absent. In this study, the hybrid MCDM model that was suggested handles the independent relations of assessment criteria with factor analysis, and it addresses the dependency relations of assessment via the use of AHP. The AHP and neutrosophic integral approaches are used for the purpose of creating synthetic usefulness in line with the environment of subjective perception. This quantitative research study explores students' readiness to continue utilizing e-learning while measuring satisfaction levels with the e-learning system among higher education students in the Gulf area. Moreover, students' behavior intention is measured here. Descriptive analysis was opted to achieve the aim of the study. Data analysis demonstrated that higher education students showed medium to high readiness levels towards e-learning and were identified with a medium level of satisfaction with the e-learning system. Moreover, students demonstrated a high intent to utilize the e-learning platform in case of offering parallel e-learning courses in the future.

Keywords: Digital Education; Students' Readiness; Online Learning; Higher Education; Middle East; Neutrosophic Sets; AHP; MCDM

1. Introduction

Many years ago, the concept of e-learning was developed to become a vital source of learning. E-learning is the alternate delivery method of learning where learners and educators are separated by physical distance. Today, e-learning has grown into a vital source of learning, method of instructional design, and content delivery through providing effective education with affordable costs. Additionally, e–learning classes are accessible at anytime and anywhere [1, 2]. In 2020, the World Health Organization (WHO) declared the spread of COVID – 19 as a global epidemic, and e-learning/online learning became the only solution for continuing learning and pursuing education degrees across the globe. The unanticipated changeover to online learning required identifying the influences that possibly will impact the dynamics of the e-learning process and investigating related issues such as students' satisfaction with e-learning their intent to remain using it, the usefulness of the e-learning to the learners, and the higher education system in the United Arab Emirates (UAE). Identifying these factors would help conclude the student's experience of the past two academic years enrolling in an online learning mode and predict their intention to continue utilizing e-learning as a learning mode. The findings of this research study will benefit higher education institutions, stakeholders, and decision-makers by presenting an investigation of students' readiness, satisfaction, and intention to continue utilizing e-learning.

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Innumerable issues have been raised since the start of e-learning: the e-learning system quality, students' satisfaction, their willingness to keep employing e-learning, and their academic success throughout being e-learning students. Multiple research studies [3, 4, 5, 6] focused on studying higher education from different perspectives, such as the major and discipline. [7] examined the issues and roles of e-learning in the UAE within the higher education sector. The findings revealed the existence of some challenges to e-learning in the UAE, including insufficient equipment, inappropriate instructions on utilizing e-learning devices, insufficient structure, and insufficient government initiatives. Thus, there is increasing demand to investigate e-learning-related to issues in the UAE to look at this inquiry to fill the gap in e-learning research in the UAE.

Digital learning has been expanding for a number of years but determining whether or not it is successful is very important for businesses considering the use of digital learning systems. There have been a significant number of studies done that place an emphasis on the aspects that should be examined while carrying out an effectiveness assessment. Several different types of assessment with their respective elements are thought about. The efficacy of digital learning is judged according to a variety of factors, many of which are interrelated and mutually influential.

The assessment models, on the other hand, are flawed and do not provide any kind of evaluation criterion. To develop an integrated assessment model, the criteria for performance assessment need to incorporate learning theories. The multi-criteria decision making (MCDM) method is suited for the assessment of e-learning since it may be assessed in accordance with a variety of elements and criteria [8].

The objective of this study is to develop a novel assessment model for the efficiency of e-learning programs that considers the tangled links and synthetic usefulness between criteria. In this study, a methodology was employed to construct the assessment methodology. The evaluation model was established based on numerous assessment criteria that were examined for the success of e-learning. In the process of evaluating e-learning, factor analysis identifies the most important components of the program and creates different factors and aspects that may then be evaluated using the AHP approach.

In practical contexts, choice criteria are often imprecise, convoluted, and inherently contradictory in their nature. In additionally, the use of crisp values in a pairwise comparison is not always correct because of the ambiguity and the ambiguous information that is accessible to those who make decisions. A growing number of scholars are beginning to use fuzzy set theory. On the other hand, fuzzy set theory merely considers the truth membership degree. Atanassov is credited with developing the intuitionistic fuzzy set theory, which considers varying degrees of truth and falsity but does not take into account indeterminacy. Smarandache proposed neutrosophic sets as a solution to the problems that had been caused by fuzzy and intuitionistic fuzzy sets. These sets consider truth, indeterminacy, and falsity levels simultaneously in order to accurately express uncertain and contradictory information. Consequently, neutrosophic sets provide a more accurate portrayal of reality. For this reason, throughout the course of our study, we made use of the AHP when it was situated inside a neutrosophic atmosphere [9, 10].

This research study intends to accomplish the following goals:

(1) Assessing the readiness to adapt to e-learning among higher education students in the UAE during the transition to online learning education, (2) Investigating students' satisfaction with the e-learning system in the UAE, and (3) students' behavioral intention to continue using it in the future.

2. Related Work

E–learning During the COVID – 19

Distance learning and online learning are two of many terms that explain the concept of e-learning. The term e-learning refers to the online educational environment where learners are separated from their educators by physical distance. According to the U.S. Department of Education, online learning can be identified as "learning that takes place partially or entirely over the Internet" [11]. In 2012, McAndrew and Johnston proposed that "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" [12]. According to a research study by [13], in which the researchers examined students' experiences integrating e-learning in two undergraduate business courses, the outcomes demonstrated that participants provided a positive review about using e-learning in their courses. Thus, the researchers suggested incorporating e-learning into some courses, fully considering variables such as learner's qualities, course content, and learning context [13].

Online learning benefits students because Distance enables students to interact and communicate, regardless of geographical limitations [14]. There is an argument among researchers regarding the effectiveness of e-

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learning; [15] suggested that achieving positive results is a challenge in online learning environments in undeveloped countries due to the lack of internet accessibility. The research study by [16], in 2021 conducted in Jordan revealed that students had a moderate preference for online learning during COVID – 19. A research study was performed by [17] in Lebanon to explore the students' experience in online learning in middle and high schools for the duration of the epidemic. The results highlighted challenges of online learning, such as poor communication between students and educators and a lack of student participation in online class activities.

[18] investigated the consequences of the COVID-19 epidemic on higher education by recognizing the challenges and struggles faced by academic programs in advancing universities from the African perspective. The results demonstrated that the pandemic enabled higher institutions to exceed their limits and develop substitutes to encourage students to pursue their education by passing the conversion to online learning and training academic instructors to create successful online instructional materials and content.

Students Satisfaction and Readiness with E-learning

Since COVID-19, online learning has become highly prevalent in many educational settings. The spread of the pandemic outbreak necessitated a transition to e-learning. The embracement of e-learning in many educational settings and the continuation of its use since the beginning of the COVID – 19 epidemics now raised the demand to investigate students' readiness for online learning and their satisfaction with the e – system effectiveness. Numerous research studies were conducted to examine this issue [19, 20, 21]. In the UAE, researchers demonstrated their interest in studying issues related to e-learning from different perspectives such as [22, 23].

Investigating the literature on students' readiness to use e-learning revealed that the concept of readiness to e-learning is familiar and has been used. A group of educators proposed the term readiness to e–learning was proposed a few decades ago in the Australian vocational education and training sector [24]. [24] suggested that readiness for e–three features can explain learning: (1) students' preferences for the method of instruction conveyance; (2) student self-confidence, competence in using online for learning and computer-mediated communication; and (3) ability to engage in self-directed learning.

Many research studies have been conducted to discuss the issues associated with e-learning, entailing students' satisfaction. [25] investigated a sample of 2196 participants representing 29 universities in Austria to investigate students' learning attainments and their satisfaction with e-learning. The study by [25] revealed a direct correlation between instructors' experiences and learning achievements as well as students' satisfaction. [26] conducted a research study in Saudi Arabia to measure students' attitudes, readiness, and satisfaction with the e-learning system. The outcomes demonstrated that students (users) are highly satisfied with e-learning and high computer skills and are ready to use it [26]. In the United States, the study by [27] examined students' perception of online learning, and the results revealed students' satisfaction with e-learning and readiness to use it. [28] examined students' perceptions of online learning in Indonesia. Results disclosed that some students preferred e–learning because they feel more interactive and engaged in e-learning.

[29] conducted a study applying the Technology Satisfaction Model to examine the factors that influence university students' satisfaction with online learning platforms in China. Purposive sampling was used to poll a total of 928 students from five institutions in four Chinese provinces or towns, and structural equation modeling and the Rasch model were used for analysis. Results demonstrate that computer self-efficacy and the platforms' perceived usability and utility have a direct and indirect impact on Chinese university students' satisfaction with online learning platforms. The results also demonstrate that regional variations modify the relationship between these components. The current study advances theoretical, methodological, and practical knowledge of how university students perceive using online learning environments, which are now acknowledged as indispensable last-resort teaching resources.

[30] performed a study aimed to investigate how students perceive and are prepared for the online learning system used at the university level during the ongoing COVID-19 pandemic and showed that students have a favorable opinion of online education and have accepted this new method of instruction.

E-learning in the UAE

Since the outbreak, the Ministry of Education (MoE) in the UAE has established a solid infrastructure system for e-learning to support the continuation of distance learning in case of facing any pandemic. The MoE in the UAE has supplied several educational resources and platforms to enable the functionality of online learning.

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Whether resources are from the MoE or come externally, they all must pass a severe evaluation cycle before embracing and implementing the Learning Management System (LMS). Multiple research studies were conducted to investigate issues attached to online learning in the UAE [31, 22]. [31] investigated undergraduate students' perceptions, attitudes, and willingness to distance learning in the UAE. The results demonstrated that language skills, motivations, and time management were the major concerns that caused students' anxiety. The MoE does its best to provide training programs for teachers to ensure that teaching and assessment are effective, particularly for the science courses that require lab work and hands-on activities. Thus, the UAE was well-equipped to adopt online learning environments compared to other countries where students face technical or financial issues [15, 32].

[33] examined the satisfaction and attitudes towards e-learning among undergraduate students in the UAE during COVID-19. The findings showed a high positive attitude and satisfaction [33]. The literature review about e-learning in the UAE focused on students' satisfaction with and attitudes concerning e-learning; however, the research regarding students' intention to continue utilizing e-learning as an alternative learning environment is unsatisfactory. Therefore, there is a need to examine higher education students' intention to continue learning online and choose e-learning as an alternative learning opportunity.

Fuzzy sets only concentrate on the membership function, which corresponds to the truth degree. They do not take into consideration the non-membership degrees, which correspond to the falsehood degree, or the indeterminacy degrees, and as a result, they are unable to accurately represent uncertainty and indeterminacy. We used the analytic hierarchy method inside a neutrosophic setting to get over the limitations that are associated with the fuzzy set.

A neutrosophic set is an extension of a classical set, a fuzzy set, and an intuitionistic fuzzy set. It successfully replicates real world situations by considering all aspects of a choice circumstance, and it is an extension of a classical set, a fuzzy set, and an intuitionistic fuzzy set (i.e., truthiness, indeterminacy and falsity)[29, 34]

3. Mathematical equations, subsections, tables, and figures

Materials and Methods

Theoretical Context

This quantitative research study adopts the three-component model that [35] presented as a theoretical context. The 34 components measure multiple components in the e-learning environments, such as students' satisfaction, readiness, and behavioral intention to continue using the e-learning platform. According to [35] model, students who are not confident in using e-learning successfully are expected to show less preference for e-learning. Based on the study objectives, the following three research questions are highly recommended.

(1) To which extent higher education students are ready to shift to online learning?
(2) What is the satisfaction level with online learning among higher education students?
(3) What is the higher education students' intent to continue using online learning?

Sample

The sample of this research study contains 468 undergraduate students distributed as (n= 190 (40.6%) males; n= 278 (59.4%)) females, enrolled in different higher education institutions in the UAE (See Figure 1), and all of them are enrolled in an e-learning environment. The sample was aged from 18 – 23 years with (M= 19.67, Mode= 19, SD= 1.2785). Participants' age categories are shown in (Table 1). Participants' level of education varied from undergraduate freshman (first year) to senior undergraduate student (fourth year) (See Figure 2). The E-learning experience was determined by participants' response to a Likert scale measurement premised on 7 – a points scale that is evaluated by 1 to indicate ''no experience'' to 7, indicating ''well experienced'' (See Figure 3). The participants are a representative sample of different cultures; however, most participants are UAE locals, as shown in (Figures 4 & 5).

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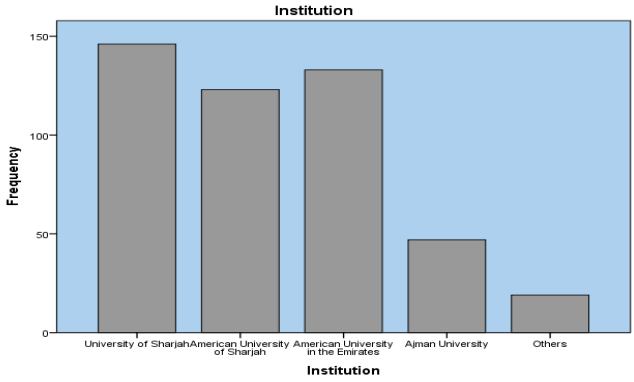

Figure 1: Presentation of participants by institution

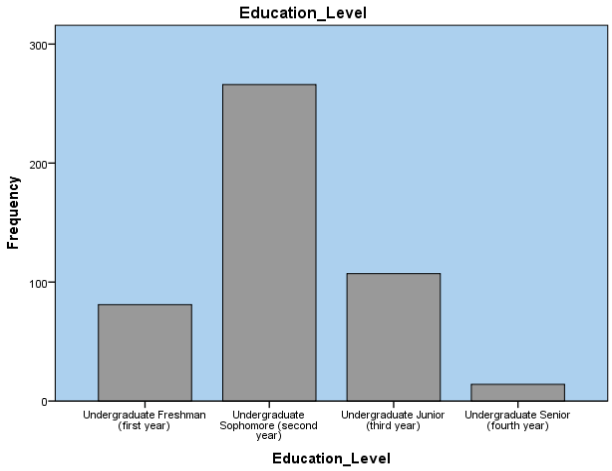

Figure 2: Presentation of participants by education level

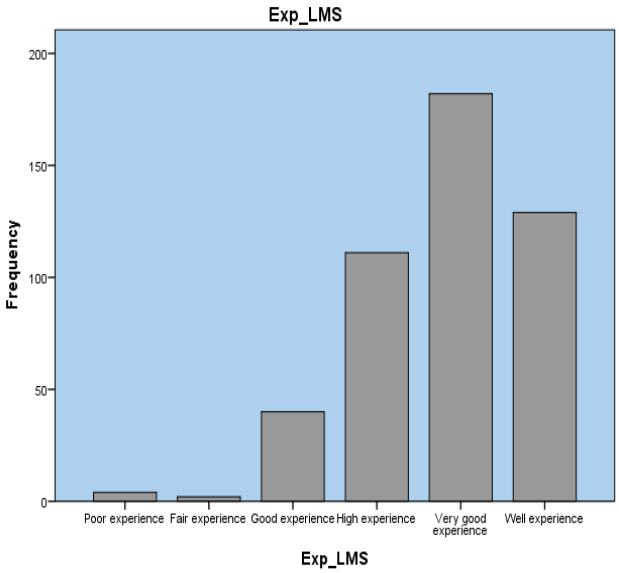

Figure 3: Presentation of participants by e – experience

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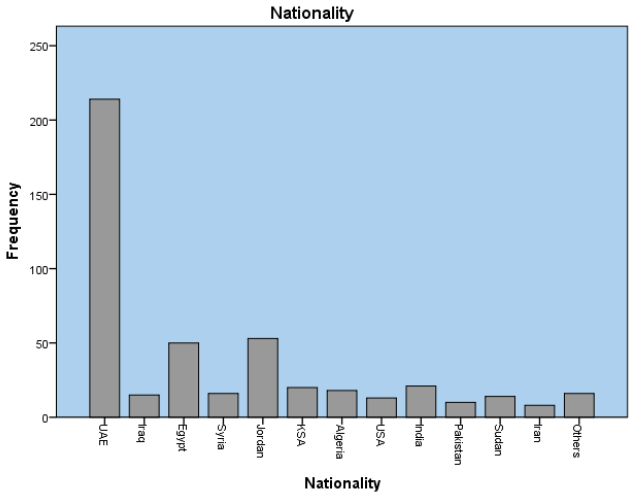

Figure 4: Presentation of participants by nationality

Table 1: Participants' distribution by age category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18.00	64	13.7	13.7	13.7
	19.00	180	38.5	38.5	52.1
	20.00	147	31.4	31.4	83.5
	21.00	35	7.5	7.5	91.0
	22.00	7	1.5	1.5	92.5
	23.00	35	7.5	7.5	100.0
	Total	468	100.0	100.0	

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 ranging from 1 = strongly disagree to 7= strongly agree. The high scores in each domain represent positive perceptions and attitudes toward the e-learning system. A positive attitude is determined by a total score higher than 4. In addition, students' experience level in e-learning is measured by a 7 – point Likert scale with 1 indicating "no experience" and 7 indicating "well experienced." The 7-point scale has been chosen here to provide an accurate scale. As it was reported by [36] that having more scale points is recommended for more accuracy.

Instrument Reliability and Validity

As stated by [37], a high internal consistency was found in the model of e-learning effectiveness and students' attitudes. Cronbach's α was evaluated by 0.97 for the model and from 0.57 to 0.80 for items' coefficients, indicating adequate measurement reliability. For this paper, Cronbach's α was computed to measure the internal reliability; it showed high reliability ranging from .661 to .894 for the scale domains and the reliability for the entire scale α = .925. As was reported by [36], achieving α values that exceed 0.7 denotes sufficient reliability (See Table 2). To evaluate the instrument's validity, the measurement scale was discussed with a

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committee of experts in the UAE region to confirm its viability and incorporation into the College of Engineering in the UAE.

Table 2**:** The internal consistency of the scale

Item	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Perceived self-efficacy	.894	.896	3
Perceived satisfaction	.852	.852	4
Perceived usefulness	.789	.794	3
Behavioral intention	.854	.855	3
e-learning system quality	.768	.772	4
Interactive learning activities	.661	.655	3
E-learning effectiveness	.774	.779	3
Multimedia instruction	.784	.785	3
Entire scale	.925	.929	26

N=468

At the beginning of Spring 2021, the second year since the transition to e-learning after the outbreak of COVID – 19 Pandemic, the researcher started the data collection process. The data collection process continued for 9 weeks. Liaw's Questionnaire was modeled on Google forms providing a detailed explanation of the study objective and nature. Furthermore, the consent form was included. The researcher emailed many instructors and professors from different universities in the UAE, asking permission to visit their e-learning classes to explain the study objectives and invite students to participate. After receiving permission, the researchers visited many virtual classes to give the students details regarding the research study's objective and the procedure to answer the questionnaire. The researcher posted the study link with guidelines and was available to reply to any questions while administering the questionnaire. Data collection was an anonymous process followed by transferring to SPSS version 22.0 for analysis and conclusion.

4. Neutrosophic AHP Method

Literature on neutrosophic sets does not seem to make use of a universally accepted symbol for a neutrosophic set as of yet. We suggest the symbol X for the neutrosophic set A, in which the three dots symbolise the components of a neutrosophic set and the T, I, F, and tilde denote that it is also a fuzzy set [38, 39].

Let E be a universe. The functions of truth-membership ($\boldsymbol{T_X}$), indeterminacy-membership ($\boldsymbol{I_X}$), and falsity-membership ($\boldsymbol{F_X}$) are what define the neutrosophic set... in E.

The real standard parts of [0,1] are denoted by the notation $\boldsymbol{T_X}(y)$, $\boldsymbol{I_X}(y)$, and $\boldsymbol{F_X}(y)$. The following equation may be used to describe a neutrosophic set denoted by X.

$$\boldsymbol{X} = \{< \boldsymbol{y}, (\boldsymbol{T_X}(\mathbf{y}), \boldsymbol{I_X}(\mathbf{y}), \boldsymbol{F_X}(\mathbf{y})) >: \boldsymbol{y} \in \boldsymbol{E}, (\boldsymbol{T_X}(\mathbf{y}), \boldsymbol{I_X}(\mathbf{y}), \boldsymbol{F_X}(\mathbf{y}) \in]-\mathbf{0}, \mathbf{1}[+)\}.$$

There is no limitation placed on the total of $\boldsymbol{T_X}(y)$, $\boldsymbol{I_X}(y)$, and $\boldsymbol{F_X}(y)$, so that 0 cannot be reduced to $\mathbf{0} \leq \boldsymbol{T_X}(\mathbf{y}) + \boldsymbol{I_X}(\mathbf{y}) + \boldsymbol{F_X}(\mathbf{y}) \leq \mathbf{3} +$.

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Let E be a universe. The truth-membership function $\boldsymbol{T_X(y)}$, the indeterminacy-membership function $\boldsymbol{I_X(y)}$, and the falsity-membership function $\boldsymbol{F_X(y)}$ are the three functions that define the single-valued neutrosophic sets A through E. The elements $\boldsymbol{I_X(y)}$; $\boldsymbol{I_X(y)}$ and $\boldsymbol{F_X(y)}$ are real standard components of the interval [0,1]. It is also possible to write it as

$$\boldsymbol{X = \{< y, (T_X(y), I_X(y), F_X(y)) >: y \in E, (T_X(y), I_X(y), F_X(y) \in [0, 1])\}}.$$

There is no limitation placed on the total of $\boldsymbol{T_X}$(y), $\boldsymbol{I_X}$(y), and $\boldsymbol{F_X}$(y), so that 0 cannot be reduced to $\boldsymbol{0 \leq T_X(y) + I_X(y) + F_X(y) \leq 3 +}$.

Let us assume that Y is a space consisting of points (objects), and that x refers to a generic component of Y. A neutrosophic set X in Y that is distinguished by the presence of a truth-membership function $\boldsymbol{T_X}$(y), an indeterminacy-membership function $\boldsymbol{I_X}$(y), and a falsity-membership function $\boldsymbol{F_X}$(y). The subsets $\boldsymbol{T_X}$(y), $\boldsymbol{I_X}$(y), and $\boldsymbol{F_X}$(y)may be classified as either actual standard or non-standard subsets. These are the

$$\boldsymbol{T_X(y): Y \rightarrow]-0, 1 +]}$$

$$\boldsymbol{I_X(y): Y \rightarrow]-0, 1 +]}$$

$$\boldsymbol{F_X(y): Y \rightarrow]-0, 1 +]}$$

First, break the issue down into its component parts using a hierarchy:

Establishing a hierarchy in the AHP technique that represents the aim, criteria, and options is necessary in order to make the issue more understandable. Within the scope of this investigation, the hierarchy of decision-making encompasses one degree of obstacles.

Building a comparison matrix pairwise involves the following steps:

With the use of the Saaty importance scale, the specialists evaluate the factors (also known as criteria) based on the relative impact of every factor Ci in comparison to Cj. When filling out the questionnaire, specialists choose a linguistic term that best conveys how critically important each component is in relation to the others. The verbal phrase is then changed to its matching numerical value, which was previously determined (i.e., 1 to 9).

Determine the consistency ratio (CR) using the following formula:

In order to determine whether or not the ratings are consistent with one another, Saaty advised doing a consistency test. Calculating a CR value allows for the testing of cardinal and output-based consistency in pairwise comparisons. This is demonstrated in Eq. (2), where the random index (RI) is dependent on the number of items being evaluated (n), and max is the maximum value of the eigenvector. If CR is less than 0.1, the expert is compelled to reevaluate their findings.

$$\boldsymbol{CR = \frac{lambda_{max} - n/n -}{RI}}$$

Neutrosophic numbers will be used in place of the linguistic information as follows:

In line with the scale, the components in the matrices for pairwise comparison are swapped out for their matching neutrosophic number.

Compiling the views of the various authorities

Choosing the ultimate importance-weights to use:

Calculations are made to determine the final important weights.

5. Results

To answer RQ 1 and find out the student's readiness in the e-learning system (measured by self-efficacy and e – experience), the descriptive analysis revealed that medium to high self–efficacy among students (M= 5.7215, SD= 1.02831) and from the e – experience scale, the majority of the students have "very good" and "well experience" as shown in (Table 3 and Figure 4). Regarding RQ 2, the descriptive analysis revealed that Liaw's domain perceived satisfaction, and results showed that students are satisfied with the e-learning (M= 5.1175, SD = 1.08921). For RQ 3, Liaw's domain of Behavioral Intention, students showed positive intention to continue using the e-learning (M= 5.4117, SD = 1.10286). For the domain Perceived Usefulness, students showed medium perception (M= 5.1859, SD = 1.20110) and for the domain e-learning effectiveness, students

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showed medium perception (M= 4.9879, SD = 1.33942). Pearson correlation coefficient *r* was conducted to quantify the strength of the linear relationship between the three variables; perceived self-efficacy, perceived satisfaction, and behavioral intention. The correlation analysis showed a medium to a strong association between the variables, which supports the accuracy of the descriptive analysis.

Table 3: The sample distribution by experience in learning management system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor experience	4	.9	.9	.9
	Fair experience	2	.4	.4	1.3
	Good experience	40	8.5	8.5	9.8
	High experience	111	23.7	23.7	33.5
	Very good experience	182	38.9	38.9	72.4
	Well experienced	129	27.6	27.6	100.0
	Total	468	100.0	100.0	

Table 4: The correlation between the three variables

		PerceivedSatisfacton_ Total	Behavioral Intention_Total	Self-efficacy_Total
Perceived Satisfaction_Total	Pearson Correlation Sig. (2-tailed)	1		
Behavioral Intention_Total	Pearson Correlation Sig. (2-tailed)	.662** .000	1	
Self- efficacy_Total	Pearson Correlation Sig. (2-tailed)	.603**	.435**	1
	N	468	468	468

** Correlation is significant at the 0.01 level (2-tailed)

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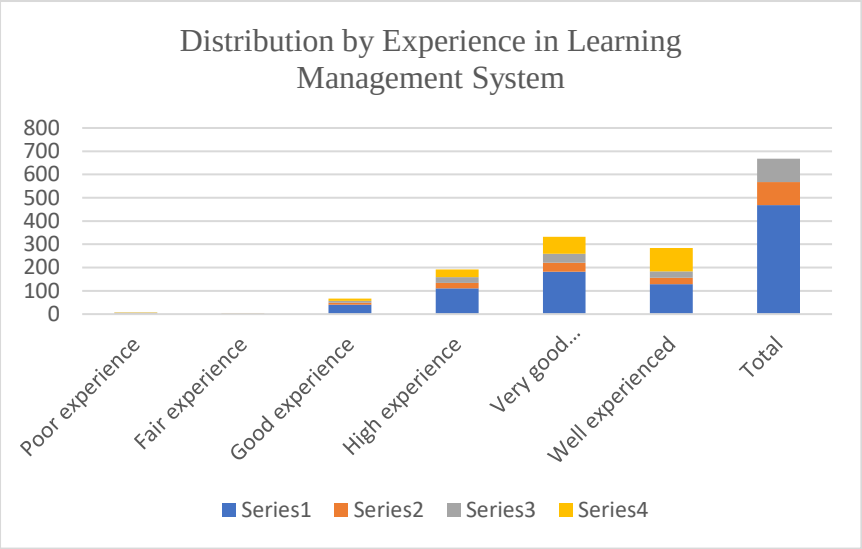

Figure 5: The sample distribution by experience in learning management system

In recent years, a new strategy for the dissemination of information, known as electronic learning (E-learning), has seen an increasing trend among younger generations. The fast improving information and communication technologies is likely to be credited for this surge. Learners are educated and given new information via the use of contemporary technology such as the internet, which is the fundamental concept behind this method. E-learning is a term that refers to a technology that is enabled by a network that educates and instructs students via the use of methods such as the internet and virtual courses.

In this decision - making problem, advantageous criteria such as features (C1), ease of maintenance (C2), ease of handling (C3), serviceability (C4), usability (C5), and effectiveness (C6) are required to have high values, whereas non-beneficial criteria such as ease of learning center (C7), personalization (C8), system subject matter (C9), and external factors (C10) are recommended to have lower values. These criteria are evaluated by three decision makers with neutrosophic numbers as shown in tables 5-7. Then convert these neutrosophic numbers to a one value. Then aggregate these values into one matrix. Then normalize the pairwise comparison matrix. Then compute the weights of criteria as shown in figure 7. From figure 7 the L10 is the highest importance and l1 is the lowest importance.

Table 5: The pairwise matrix one between 10 criteria

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
L1	1	<0.9,0.1,0.2>	<0.8,0.2,0.3>	<0.8,0.2,0.3>	<0.7,0.3,0.4>	<0.9,0.1,0.2>	<0.3,0.8,0.9>	<0.9,0.1,0.2>	<0.3,0.8,0.9>	<0.7,0.3,0.4>
L2	1/<0.9,0.1,0.2>	1	<0.3,0.8,0.9>	<0.9,0.1,0.2>	<0.3,0.8,0.9>	<0.8,0.2,0.3>	<0.3,0.8,0.9>	<0.4,0.7,0.8>	<0.8,0.2,0.3>	<0.9,0.1,0.2>
L3	1/<0.8,0.2,0.3>	1/<0.3,0.8,0.9>	1	<0.3,0.8,0.9>	<0.9,0.1,0.2>	<0.4,0.7,0.8>	<0.3,0.8,0.9>	<0.7,0.3,0.4>	<0.4,0.7,0.8>	<0.3,0.8,0.9>
L4	1/<0.8,0.2,0.3>	1/<0.9,0.1,0.2>	1/<0.3,0.8,0.9>	1	<0.3,0.8,0.9>	<0.7,0.3,0.4>	<0.8,0.2,0.3>	<0.3,0.8,0.9>	<0.4,0.7,0.8>	<0.8,0.2,0.3>
L5	1/<0.7,0.3,0.4>	1/<0.3,0.8,0.9>	1/<0.9,0.1,0.2>	1/<0.3,0.8,0.9>	1	<0.9,0.1,0.2>	<0.7,0.3,0.4>	<0.4,0.7,0.8>	<0.7,0.3,0.4>	<0.4,0.7,0.8>
L6	1/<0.9,0.1,0.2>	1/<0.8,0.2,0.3>	1/<0.4,0.7,0.8>	1/<0.7,0.3,0.4>	1/<0.9,0.1,0.2>	1	<0.3,0.8,0.9>	<0.7,0.3,0.4>	<0.3,0.8,0.9>	<0.8,0.2,0.3>
L7	1/<0.3,0.8,0.9>	1/<0.3,0.8,0.9>	1/<0.3,0.8,0.9>	1/<0.8,0.2,0.3>	1/<0.7,0.3,0.4>	1/<0.3,0.8,0.9>	1	<0.9,0.1,0.2>	<0.4,0.7,0.8>	<0.7,0.3,0.4>

L8	1/<0.9, 0.1,0.2>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1	<0.9,0. 1,0.2>	<0.9,0. 1,0.2>
L9	1/<0.3, 0.8,0.9>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.4, 0.7,0.8>	1/<0.9, 0.1,0.2>	1	<0.4,0. 7,0.8>
L10	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1/<0.3, 0.8,0.9>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.8, 0.2,0.3>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1/<0.4, 0.7,0.8>	1

Table 6: The pairwise matrix two between 10 criteria

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
L1	1	<0.9,0. 1,0.2>	<0.4,0. 7,0.8>	<0.8,0. 2,0.3>	<0.4,0. 7,0.8>	<0.9,0. 1,0.2>	<0.3,0. 8,0.9>	<0.4,0. 7,0.8>	<0.3,0. 8,0.9>	<0.4,0. 7,0.8>
L2	1/<0.9, 0.1,0.2>	1	<0.3,0. 8,0.9>	<0.9,0. 1,0.2>	<0.3,0. 8,0.9>	<0.8,0. 2,0.3>	<0.4,0. 7,0.8>	<0.4,0. 7,0.8>	<0.8,0. 2,0.3>	<0.9,0. 1,0.2>
L3	1/<0.4, 0.7,0.8>	1/<0.3, 0.8,0.9>	1	<0.3,0. 8,0.9>	<0.9,0. 1,0.2>	<0.4,0. 7,0.8>	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>	<0.4,0. 7,0.8>	<0.4,0. 7,0.8>
L4	1/<0.8, 0.2,0.3>	1/<0.9, 0.1,0.2>	1/<0.3, 0.8,0.9>	1	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>	<0.8,0. 2,0.3>	<0.4,0. 7,0.8>	<0.4,0. 7,0.8>	<0.8,0. 2,0.3>
L5	1/<0.4, 0.7,0.8>	1/<0.3, 0.8,0.9>	1/<0.9, 0.1,0.2>	1/<0.3, 0.8,0.9>	1	<0.9,0. 1,0.2>	<0.7,0. 3,0.4>	<0.4,0. 7,0.8>	<0.7,0. 3,0.4>	<0.4,0. 7,0.8>
L6	1/<0.9, 0.1,0.2>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>	<0.3,0. 8,0.9>	<0.4,0. 7,0.8>
L7	1/<0.3, 0.8,0.9>	1/<0.4, 0.7,0.8>	1/<0.3, 0.8,0.9>	1/<0.8, 0.2,0.3>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1	<0.4,0. 7,0.8>	<0.4,0. 7,0.8>	<0.7,0. 3,0.4>
L8	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.4, 0.7,0.8>	1	<0.9,0. 1,0.2>	<0.4,0. 7,0.8>
L9	1/<0.3, 0.8,0.9>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.4, 0.7,0.8>	1/<0.9, 0.1,0.2>	1	<0.4,0. 7,0.8>
L10	1/<0.4, 0.7,0.8>	1/<0.9, 0.1,0.2>	1/<0.4, 0.7,0.8>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.4, 0.7,0.8>	1/<0.4, 0.7,0.8>	1

Table 7: The pairwise matrix three between 10 criteria

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
L1	1	<0.9,0. 1,0.2>	<0.7,0. 3,0.4>	<0.8,0. 2,0.3>	<0.7,0. 3,0.4>	<0.9,0. 1,0.2>	<0.3,0. 8,0.9>	<0.9,0. 1,0.2>	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>
L2	1/<0.9, 0.1,0.2>	1	<0.3,0. 8,0.9>	<0.9,0. 1,0.2>	<0.3,0. 8,0.9>	<0.8,0. 2,0.3>	<0.7,0. 3,0.4>	<0.7,0. 3,0.4>	<0.8,0. 2,0.3>	<0.7,0. 3,0.4>
L3	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1	<0.7,0. 3,0.4>	<0.9,0. 1,0.2>	<0.4,0. 7,0.8>	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>	<0.7,0. 3,0.4>	<0.3,0. 8,0.9>
L4	1/<0.8, 0.2,0.3>	1/<0.9, 0.1,0.2>	1/<0.7, 0.3,0.4>	1	<0.3,0. 8,0.9>	<0.7,0. 3,0.4>	<0.7,0. 3,0.4>	<0.3,0. 8,0.9>	<0.4,0. 7,0.8>	<0.7,0. 3,0.4>

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L5	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.9, 0.1,0.2>	1/<0.3, 0.8,0.9>	1	<0.7,0.3,0.4>	<0.7,0.3,0.4>	<0.7,0.3,0.4>	<0.7,0.3,0.4>	<0.4,0.7,0.8>
L6	1/<0.9, 0.1,0.2>	1/<0.8, 0.2,0.3>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.7, 0.3,0.4>	1	<0.3,0.8,0.9>	<0.7,0.3,0.4>	<0.3,0.8,0.9>	<0.8,0.2,0.3>
L7	1/<0.3, 0.8,0.9>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.7, 0.3,0.4>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1	<0.9,0.1,0.2>	<0.7,0.3,0.4>	<0.7,0.3,0.4>
L8	1/<0.9, 0.1,0.2>	1/<0.7, 0.3,0.4>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.7, 0.3,0.4>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1	<0.9,0.1,0.2>	<0.9,0.1,0.2>
L9	1/<0.3, 0.8,0.9>	1/<0.8, 0.2,0.3>	1/<0.7, 0.3,0.4>	1/<0.4, 0.7,0.8>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1	<0.7,0.3,0.4>
L10	1/<0.7, 0.3,0.4>	1/<0.7, 0.3,0.4>	1/<0.3, 0.8,0.9>	1/<0.7, 0.3,0.4>	1/<0.4, 0.7,0.8>	1/<0.8, 0.2,0.3>	1/<0.7, 0.3,0.4>	1/<0.9, 0.1,0.2>	1/<0.7, 0.3,0.4>	1

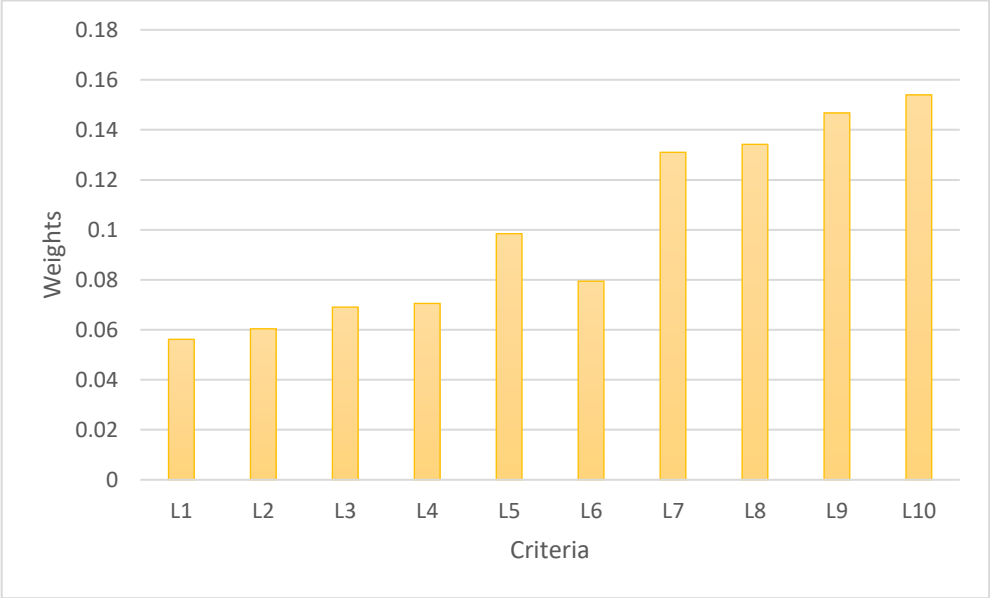

Figure 7: The 10 criteria weights.

6. Discussion

The main goal of this research study is to investigate higher education students' readiness, satisfaction with the e-learning system, and their behavioral intention to continue using e-learning in the future in the UAE. Findings indicated a medium to high readiness level to learn and continue enrolling in e-learning environments in higher education settings. These findings could be interpreted as students' high technical abilities increasing their readiness level for e-learning. Moreover, students showed a medium level of satisfaction with the e-learning environment. These results can be interpreted as the Ministry of Education in the UAE doing its best to enhance the e-learning system through continuous training and assessment, which enables students to master using the e-learning system and feel competent to continue embracing e-learning as a platform for learning and development. These results are in agreement with [40, 41] who examined students' satisfaction with the e-learning platform and revealed that students are satisfied with the e-learning approach. These findings could be explained in the context of the well-preparation that higher education institutions offered to help students develop e-skills. Moreover, findings are consistent with [13, 37, 26] who discovered that college students have a positive attitude toward e-learning. These findings could be integrated into the higher education sector effectively, such as by offering hybrid courses even after reverting to face–to–face mode of learning. The findings of students' behavioral intention to use e-learning platforms showed that students have a high intention level to continue using the digital education/e-learning, which could be interpreted that students' perception of the importance and benefits of e-learning play a vital role in indicating the students'

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intention to adapt to the e-learning environment. These results are coherent with the conclusions of [25] who examined students' intention to use e-learning. Students' readiness to use e-learning can be interpreted as undergraduate students with ages ranging from 18 – 24, which means they are digital natives [42] and are expected to show positive satisfaction with e-learning systems. The results of the correlation between the three variables under inquire demonstrate the accuracy of the outcomes of the measured variables.

7. Conclusions

This quantitative research paper was performed to determine students' readiness and satisfaction with e-learning among college students in the Emirates. Higher education students were identified with medium to high readiness to use e-learning in the future, reflecting their high technical skills. Moreover, students were satisfied with the e–learning system provided by their institutions, which reflects the efforts to improve e-learning in the UAE. Higher education students are willing to continue utilizing e-learning in the future if it is an alternative education mode.

This study incorporated numerous ways to bring the suggested model, the hybrid MCDM model, closer to reality. The hybrid MCDM model with the neutrosophic sets should be a feasible and helpful model to assess the efficacy of e-learning and to demonstrate the interrelations of entangled criteria, according to the findings of empirical investigation. Because of this, if the efficacy of an e-learning program is inadequate, we would be able to identify the cause of the issue by using neutrosophic AHP weights and the interrelationships shown by the impact-digraph-map of each element. Evaluators were able to identify the components of the e-learning program that need improvement after utilizing this model to evaluate the efficacy of e-learning. This allowed the effectiveness of e-learning programs to be increased. When compared to conventional methods of evaluating e-learning, this model considers a greater number of factors and criteria that have the potential to influence the efficiency of an e-learning program.

8. Limitations and Recommendations

This study underlies the simple linear regression as it looks at the linear relationship between two variables, the dependent and independent variables, so it presumes there is a straight-line relationship between the two variables, which is incorrect in some cases. The findings of this research paper propose the following suggestions to educators, higher education policymakers, stakeholders, and decision-makers, to consider when offering e-learning as an alternative learning environment.

(1) Conducting readiness assessment for e-learning by distributing surveys to students at the beginning of each semester or academic year.

(2) Offer hybrid courses that contain a dual approach; online and face-to-face modules to prepare students for the distance learning transition.

(3) Including more teaching and different assessment forms to increase the effectiveness of e-learning.

(4) Including advanced software such as simulations to help students imagine and create more designs to their course content to enhance their learning ability.

Upcoming research should emphasize considering the influence of the domains of Liaw's (2008) on high school students and discover whether enrolling in the e-learning system influences their academic success or not.

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