



# Neutrosophic-Operational and Multi-Decision Analysis Study for Meeting the Demands of FinTech Education Marketing

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## Abstract

FinTech marketing education poses unique challenges that require new research directions. The constantly-evolving nature of the industry, coupled with the need to keep pace with technological advancements, demands an innovative approach to curriculum design and evaluation. Traditional education methods may not be sufficient to prepare students for careers in FinTech marketing, emphasizing the need for a multi-dimensional evaluation framework that considers business requirements, market trends, and customer needs. A Neutrosophic-Operational and Multi-Decision Analysis approach can provide a new direction for research, enabling educators to meet the evolving needs of the industry and better prepare students for successful careers in FinTech marketing. Throughout this article, we demonstrate a hybrid application of the Neutrosophic-AHP and the Multi-Criteria Decision Analysis technique for determining and assessing the most important characteristics of e-learning systems in the field of sustainability science education. Sustainability, scientific education, e-learning, and technological criterion are some of the most important to consider in order to reach this stated objective. The participative neutrosophic AHP method examined sixteen sub-criteria in terms of the value and calculation of coefficients within the framework of impact and evaluation. The most crucial factors for the ultimate choice issue are gathered. Therefore, techniques such as neutrosophic-operational and multi-decision analysis, as well as expert surveys, may be used to identify the most important criteria for e-learning in the field of sustainability science, which can then be employed to develop adaptable and relevant decision features.

**Keywords:** Neutrosophic Sets; MCDM; AHP; E-Learning; Higher Education; Sustainability; FinTech education marketing

## 1. Introduction

FinTech marketing education presents unique challenges due to the complex and rapidly-changing nature of the industry. As such, there is a growing need for a comprehensive evaluation framework that can address the multi-dimensional requirements of FinTech marketing education. Neutrosophic-Operational and Multi-Decision Analysis is a promising approach that can provide such a framework. It is a comprehensive evaluation method that takes into account both the subjective and objective aspects of a problem and provides a more accurate and robust analysis.

The use of Neutrosophic-Operational and Multi-Decision Analysis in FinTech marketing education is particularly relevant due to the high level of uncertainty and ambiguity associated with the industry.

With the increasing use of artificial intelligence and machine learning in FinTech marketing, there is a growing need for a more sophisticated approach to evaluation that can take into account these complexities. Neutrosophic-Operational and Multi-Decision Analysis can provide a more accurate and reliable evaluation framework that can take into account these uncertainties and help educators make more informed decisions about the design and delivery of FinTech marketing education.

Increasing public awareness of sustainability concerns coincides with the expansion of scientific courses offered online through cutting-edge e-learning platforms based on cutting-edge new information and communication technologies (ICTs) [1], [2]. Many factors, including new competencies, flexibility, and competitiveness among institutions, must be met before sustainable scientific teaching can be implemented in higher education [3], [4]. For long-term success in sustainable development, new information and ICTs in scientific e-learning education systems have a strong linkage [5]. E-learning programs, which may replace the existing educational void, have been the focus of the technical problems incorporated into SSE here [6]. E-learning systems' vast variety and evaluation for launching e-learning systems' ranking, as well as the neutrosophic- AHP approach, has been used to establish an operational organization amongst the criteria and value. Many elements and components of e-learning associated with applications using the neutrosophic AHP have been examined to illustrate the full qualifications and experiences, which are equal for both e-learning and traditional methods [7]. Because of the reasons and lack of literature, e-learning systems in SSE need to be scrutinized for their criteria and sub-criteria. As a result, the study proposed will fill in the existing knowledge gap and provide an overview of the current state of the art in the area addressed.

SE is facilitated by the use of ICTs, which allow for flexible and relevant learning processes through e-learning and online learning [5]. When used in conjunction with e-learning platforms, the ICTs allow for several modes of communication to take place, including instructor-to-student and student to peer. For SE, an e-learning system is especially concerned with the freedom of time and place, a self-restricted learning process, and inter- and multi-disciplinary advancement in teaching/learning[1]. According to [8], e-learning students often have a higher feeling of knowledge, which leads to effective transformational learning, as do other scholars [9]. According to [10], students' educational outcomes are closely linked to e-learning systems' characteristics, which include learning tactics that are flexible and multi-directional knowledge transfer. Students' improved learning outcomes are linked to all critical sustainability education topics when they participate in self-regulated and cooperative learning processes [11]. Science e-learning education systems, in addition to ICTs and new materials, might have a significant impact on long-term and lifelong learning, along with many criteria [12]. Also, e-learning programs, which may address the existing educational gap, have been the focus of the technology challenge incorporated into SSE [10]. ICT-based teaching and learning in sustainability education are examined in this field, which focuses on the integration of transformative teaching/learning and sustainability concerns [13]. Traditional online classrooms, on the other hand, still have a greater need for further investigation into the practicality of e-learning methods. The assessment and discussion of current publications in university education for SSE e-learning education systems show that explanation and extensive analysis are needed in higher education [13]. For this reason, it is necessary to include many criteria in an e-learning system that may be used by a variety of stakeholders in SSE.

Consciousness-raising and lifetime education quality are becoming more important in numerous educational sectors as a result of SE [1]. Decades of Education for Sustainable Development (DESD) and the UNESCO 2015–2030 Plan have been aiming to include SE's goals, principles, and practices [14] in the United Nations (UN). Students at universities in the higher education sector should be given the competence and knowledge to change their behavior via SE [15]. It is focused on the development of competencies in the areas of skills, information, knowledge, and worth; the academic curricula are reoriented, and the notion of sustainability is better understood. A SE is an educational culture transformation that will lead to transformative learning, according to Sterling. In [16] transformational learning, he emphasized the role of instructors who may help learners achieve more self-reliant and trustworthy objectives. Instructional advances and resolutions in the instructional culture focus on apprentices as well as the ability to communicate and think in a way that aids in the transition to a sustainable future [17]. The ideas of sustainable education are intertwined with the practice of teaching and learning. In addition, it does not link a specific study field that may be characterized by its measures, techniques, and proficiencies as well as scientific dexterity and proficiency[18]. An emerging field in educational science, it has a close connection to SE [19]. SSE is still in its infancy at many institutions, even though it has played an important role in informing academics, entrepreneurs, and leaders to help improve communities and cultures. Since the features

of universities are changing at a very gradual pace, it is vital to reflect this fact [1]. A pedagogical perspective act for filling an e-learning system niche may be produced by continuous (science) education in difficult settings.

Multi-Criteria Decision Analysis (MCDA) is a powerful tool that may be used in a wide range of decision-making circumstances, even when the decision-makers involved have divergent viewpoints and differing criteria and sub-criteria to take into account [20]. The analytic Hierarchy Process (AHP) is an important tool for assessing prospective components for sustainability (science) education using e-learning platforms, whereas MCDA is a key approach and instrument used in several foundations and disciplines [21]. The large range of e-learning systems available has been singled out for its role in kicking off systems of multi-criteria learning decision-making. They also proposed a weighted distance-based approximation approach with an optimal elucidation similarity comparison based on MCDA challenges [22]. To make better judgments, [23] created standards and criteria for e-learning solutions that were designed to finance customers and management systems of e-learning instruments.

The paper is organized into four main sections. Section 1 introduces the challenges of FinTech Education Marketing and the possibilities of using Neutrosophic sets to avoid them. Section 2 discusses the main preliminaries in Neutrosophic-Operational and Multi-Decision Analysis. Section 3 discusses our research findings. The conclusion is included in section 4.

## 2. Preliminaries in Neutrosophic-Operational and Multi-Decision Analysis

The neutrosophic-Operational analysis is a relatively new method that has been gaining attention for its ability to handle uncertain, incomplete, and indeterminate data in decision-making processes. It provides a comprehensive framework for evaluating multi-dimensional problems by considering three components: truth membership, indeterminacy membership, and falsity membership. This allows for a more nuanced evaluation of complex issues and can provide insights that traditional methods may not be able to capture. Multi-Decision Analysis is another important tool for evaluating complex problems by considering multiple decision criteria. By combining these two methods, researchers can develop an innovative approach to evaluating the requirements of FinTech marketing education in online settings, providing a comprehensive framework for educators to better prepare students for the dynamic and complex nature of the industry. Our definitions in this area include terms such as "ultra-neutrosophic crisp set," "neutrosophic sets," and "neutrosophic crisp set NCS." [24]–[27]

### Definition 1.

*Assume that  $X$  is a nonempty fixed set.*

*Then  $BN$ , an NCS is a triplet defined by*

$$BN = (Q_1, Q_2, Q_3), \text{ where } Q_a (a = 1, 2, 3)$$

*be any subset of  $X$ .*

### Definition 2.

*Suppose that  $BN = (Q_1, Q_2, Q_3)$  is an NCS.*

*Then, the complement of  $BN = (Q_1, Q_2, Q_3)$*

$$\text{is defined by } B_N^c = (Q_1^c, Q_2^c, Q_3^c).$$

### Definition 3.

*Assume that  $BN = (Q_1, Q_2, Q_3)$  and*

$$AN = (Q_1, R_2, R_3) \text{ are any two NCSs.}$$

*Then,*

$$BN \subseteq AN \text{ if } Q_1 \subseteq R_1, Q_2 \subseteq R_2, Q_3 \supseteq R_3;$$

$$BN \cup AN = (Q_1 \cup R_1, Q_2 \cup R_2, Q_3 \cap R_3);$$

$$BN \cap AN = (Q_1 \cap R_1, Q_2 \cap R_2, Q_3 \cup R_3).$$

**Definition 4.**

Assume that  $X$  is a fixed set.

Then, an UNCS  $\widetilde{B}_N$  is defined as follows:

$$\widetilde{B}_N = (Q_1, Q_2, Q_3, D_Q), \text{ where } D_Q = (\cup_{a=1}^3 Q_a)^c.$$

**Definition 5.**

Assume that  $\widetilde{B}_N = (Q_1, Q_2, Q_3, D_Q)$  and

$\widetilde{A}_N = (R_1, R_2, R_3, D_R)$  are two UNCSs.

Then ,

$$\widetilde{B}_N \subseteq \widetilde{A}_N \text{ if } Q_1 \subseteq R_1, Q_2 \subseteq R_2, Q_3 \supseteq R_3, D_Q \supseteq D_R;$$

$$\widetilde{B}_N \cup \widetilde{A}_N = (Q_1 \cup R_1, Q_2 \cup R_2, Q_3 \cap R_3, D_Q \cap D_R);$$

$$\widetilde{B}_N \cap \widetilde{A}_N = (BQ_1 \cap R_1, Q_2 \cap R_2, Q_3 \cup R_3, D_Q \cup D_R).$$

**Definition 6.**

Suppose that  $X$  is a fixed set.

Then, an NS  $A$  over  $X$  is defined as follows:

$$A = \{(w, Tr_A(w), Ind_A(w), FL_A(w)) :$$

$$w \in X, \text{ and } Tr_A(w), Ind_A(w), FL_A(w) \in ]$$

$$-0, 1 + [, \text{ where } -0 \leq Tr_A(w) + Ind_A(w) + FL_A(w) \leq 3+.$$

**Definition 7.**

Assume that  $A = \{(w, Tr_A(w), Ind_A(w), FL_A(w)) :$

$w \in A, \text{ and } Tr_A(w), Ind_A(w), FL_A(w) \in [0, 1]\}$

be an NS over a fixed set  $A$ .

Then, the complement of  $A$

$$\text{is } A^c = \{(w, 1 - Tr_A(w), 1 - Ind_A(w), 1 - FL_A(w)) : w \in X\}.$$

**Definition 8.**

Assume that  $A = \{(w, r_A(w), Ind_A(w), FL_A(w)) :$

$w \in X, \text{ and } r_A(w), Ind_A(w), FL_A(w) \in [0, 1]\}$

and  $H = \{(w, r_A(w), Ind_A(w), FL_A(w)) :$

$w \in X, \text{ and } r_A(w), Ind_A(w), FL_A(w) \in [0, 1]\}$

be two NSs over  $X$ .

Then,

$$A \subseteq H \text{ if } Tr_{A(w)} \leq Tr_{H(w)}, Ind_{A(w)} \geq Ind_{H(w)},$$

$$FL_{A(w)} \geq FL_{H(w)},$$

for each  $w \in X$ .

$$A \cup H = \{(w, Tr_A(w) \vee Tr_H(w), \\ Ind_A(w) \wedge Ind_H(w), \\ FL_A(w) \wedge FL_H(w)) : \\ w \in X\};$$

$$A \cap H = \{(w, Tr_A(w) \wedge Tr_H(w), \\ Ind_A(w) \vee Ind_H(w), \\ FL_A(w) \vee FL_H(w)) : \\ w \in X\};$$

**Definition 9.**

The null NS (ME) and the whole NS (1E) over a fixed set  $X$  are defined as follows:

$$ME = \{(w, 0, 0, 1) : w \in X\};$$

$$1E = \{(w, 1, 0, 0) : w \in X\}.$$

$$ME \subseteq A \subseteq 1E,$$

for any NS  $A$  over a fixed set  $X$ .

**Definition 10.**

An ultra neutrosophic set  $U$

over a nonempty set  $X$  is defined by

$$U = \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\},$$

where  $D_{U(w)} = Tr_{U(w)} \wedge Ind_{U(w)} \wedge FL_{U(w)}$ ,

$$\forall w \in X \text{ or}$$

$$D_{U(w)} = Tr_{U(w)} \vee Ind_{U(w)} \vee FL_{U(w)}, \forall w \in X.$$

**Definition 11.**

$$U = \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\}$$

$$\text{and } K = \{(w, Tr_{K(w)}, Ind_{K(w)}, FL_{K(w)}, D_{K(w)}) : w \in X\}$$

over a fixed set  $X$ .

Then,

$$U \subseteq K \Leftrightarrow Tr_{U(w)} \leq Tr_{K(w)}, Ind_{U(w)} \geq Ind_{K(w)},$$

$$FL_{U(w)} \geq FL_{K(w)},$$

$$D_{U(w)} \leq D_{K(w)},$$

for each  $w \in X$ ;

$U = K$  if and only if

$$U \subseteq K \text{ and } K \subseteq U;$$

$$U \cup K = \{(w, Tr_{U(w)} \vee Tr_{K(w)}, \\ Ind_{U(w)} \wedge Ind_{K(w)}, \\ FL_{U(w)} \wedge FL_{K(w)}, D_{U(w)} \vee D_{K(w)}) \\ : w \in X\};$$

$$U \cap K = \{(w, Tr_{U(w)} \wedge Tr_{K(w)}, \\ Ind_{U(w)} \vee Ind_{K(w)}, \\ FL_{U(w)} \vee FL_{K(w)}, D_{U(w)} \wedge D_{K(w)}) \\ : w \in X\};$$

$$FL_U(w) \vee FL_K(w), D_U(w) \wedge D_K(w) \\ : w \in X \};$$

**Definition 12.**

The null UNS  $\widehat{M}_E$  and the whole UNS  $\widehat{1}_E$  over a fixed set  $X$  is defined as follows:

$$\widehat{M}_E = \{(w, 0, 1, 1, 0) : w \in X\}; \\ \widehat{1}_E = \{(w, 1, 0, 0, 1) : w \in X\}. \\ \text{Clearly, } \widehat{M}_E \subseteq A \subseteq \widehat{1}_E,$$

for any UNS  $A$  over  $X$ .

**Theorem 1.**

Let  $S, U,$  and  $V$  be three UNSs over a fixed set  $X$ .

Then, the following results hold:

$$1/ S \cup [U \cup V] = [S \cup U] \cup V; \\ 2/ S \cap [U \cap V] = [S \cap U] \cap V; \\ 3/ S \cup U = U \cup S \text{ and } S \cap U = U \cap S; \\ 4/ S \cup S = S \text{ and } S \cap S = S; \\ 5/ S \cup [U \cap V] = [S \cup U] \cap [S \cup V]; \\ 6/ S \cap [U \cup V] = [S \cap U] \cup [S \cap V]; \\ 7/ [S \cup V] \cup V = S.$$

**Proof**

Assume that  $S = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\}$ ,

$U = \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\}$  and

$V = \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}) : w \in X\}$

be 3 UNSs over a fixed set  $X$ .

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$$S \cup [U \cup V] \\ = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\ \cup \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\} \\ \cup \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}) : w \in X\} \\ = \{(w, TTr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in Z\} \\ \cup \{(w, Tr_U(w) \vee Tr_V(w), Ind_U(w) \wedge Ind_V(w), \\ FL_U(w) \wedge FL_V(w), D_U(w) \vee D_V(w)) : w \in X\} \\ = \{(w, Tr_S(w) \vee (Tr_U(w) \vee Tr_V(w)), Ind_S(w) \wedge (Ind_U(w) \wedge Ind_V(w)), \\ FL_S(w) \wedge (FL_U(w) \wedge FL_V(w)), D_S(w) \vee (M_U(w) \vee M_V(w))) : w \in X\} \\ = \{(w, (Tr_S(w) \vee Tr_U(w)) \vee Tr_V(w), (Ind_S(w) \wedge Ind_U(w)) \wedge Ind_V(w), \\ (FL_S(w) \wedge FL_U(w)) \wedge FL_V(w), (D_S(w) \vee D_U(w)) \vee D_V(w)) : w \in X\} \\ = \{(w, Tr_S(w) \vee Tr_U(w), Ind_S(w) \wedge Ind_U(w), FL_S(w) \wedge FL_U(w), D_S(w) \vee D_U(w)) : w \in X\} \cup \\ \{(w, Tr_V(w), Ind_V(w), FL_V(w), D_V(w)) : w \in X\} \\ = [\{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\ \cup \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\}]$$

$$\begin{aligned} & \cup \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}): w \in X\} \\ & = [S \cup U] \cup \mathcal{N} \\ So, S \cup [U \mathcal{N}] & = [S \cup U] \cup \mathcal{N}. \end{aligned}$$

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$$\begin{aligned} & \text{We prove, } S \cap [U \cap V] \\ & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \\ & \cap \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & \cap \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}): w \in X\} \\ & = \{(w, TTr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in Z\} \\ & \cap \{(w, Tr_U(w) \vee Tr_V(w), Ind_U(w) \vee Ind_V(w), \\ & FL_U(w) \vee FL_V(w), D_U(w) \wedge D_V(w)): w \in X\} \\ & = \{(w, Tr_S(w) \wedge (Tr_U(w) \wedge Tr_V(w)), Ind_S(w) \vee (Ind_U(w) \vee Ind_V(w)), \\ & FL_S(w) \vee (FL_U(w) \vee FL_V(w)), D_S(w) \wedge (M_U(w) \wedge M_V(w))): w \in X\} \\ & = \{(w, (Tr_S(w) \wedge Tr_U(w)) \wedge Tr_V(w), (Ind_S(w) \wedge Ind_U(w)) \wedge Ind_V(w), \\ & (FL_S(w) \vee FL_U(w)) \vee FL_V(w), (D_S(w) \vee D_U(w)) \vee D_V(w)): w \in X\} \\ & = \{(w, Tr_S(w) \wedge Tr_U(w), Ind_S(w) \vee Ind_U(w), FL_S(w) \vee FL_U(w), D_S(w) \\ & \wedge D_U(w)): w \in X\} \wedge \\ & \{(w, Tr_V(w), Ind_V(w), FL_V(w), D_V(w)): w \in X\} \\ & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \\ & \wedge \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & \wedge \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}): w \in X\} \\ & = [S \wedge U] \wedge V \\ So, S \wedge [U \wedge V] & = [S \wedge U] \wedge V. \end{aligned}$$

3/

$$\begin{aligned} & \text{We prove, } S \cup U \\ & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \\ & \vee \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & = \{(w, Tr_S(w) \vee Tr_U(w), Ind_S(w) \wedge Ind_U(w), FL_S(w) \wedge FL_U(w), D_S(w) \vee D_U(w)): w \in X\} \\ & \{(w, Tr_U(w) \vee Tr_S(w), Ind_U(w) \wedge Ind_S(w), FL_U(w) \wedge FL_S(w), D_U(w) \vee D_S(w)): w \in X\} \\ & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \cup \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & = U \cup S \end{aligned}$$

Therefore,  $S \cup U = U \cup S$ .

Further, we have  $S \cap U$

$$\begin{aligned} & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \\ & \wedge \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & = \{(w, Tr_S(w) \wedge Tr_U(w), Ind_S(w) \vee Ind_U(w), FL_S(w) \vee FL_U(w), D_S(w) \wedge D_U(w)) \\ & : w \in X\} \\ & \{(w, Tr_U(w) \wedge Tr_S(w), Ind_U(w) \vee Ind_S(w), FL_U(w) \vee FL_S(w), D_U(w) \wedge D_S(w)): w \in X\} \\ & = \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}): w \in X\} \cap \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}): w \in X\} \\ & = U \cap S \end{aligned}$$

Therefore,  $S \cap U = U \cap S$ .

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$$\begin{aligned}
 & N \cup N \\
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &\vee \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &= \{(w, Tr_S(w) \vee Tr_S(w), Ind_S(w) \wedge Ind_S(w), FL_S(w) \wedge FL_S(w), D_S(w) \vee D_S(w)) : w \in X\} \\
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &= S \\
 &\text{Therefore, } S \cup S = S.
 \end{aligned}$$

Further, we have  $S \cap S$

$$\begin{aligned}
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &\wedge \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &= \{(w, Tr_S(w) \wedge Tr_S(w), Ind_S(w) \vee Ind_S(w), FL_S(w) \vee FL_S(w), D_S(w) \wedge D_S(w)) : w \in X\} \\
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} = S \\
 &\text{Therefore, } S \cap S = S.
 \end{aligned}$$

$$\begin{aligned}
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &\cup \{(w, Tr_U(w), Ind_U(w), FL_U(w), D_U(w)) : w \in X\} \\
 &\sqcap \{(w, Tr_V(w), Ind_V(w), FL_V(w), D_V(w)) : w \in X\} \\
 &= \{(w, TTr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in Z\} \\
 &\cup \{(w, Tr_U(w) \wedge Tr_V(w), Ind_U(w) \vee Ind_V(w), \\
 &FL_U(w) \vee FL_V(w), D_U(w) \wedge D_V(w)) : w \in X\} \\
 &= \{(w, Tr_S(w) \vee (Tr_U(w) \wedge Tr_V(w)), Ind_S(w) \wedge (Ind_U(w) \vee Ind_V(w)), \\
 &FL_S(w) \wedge (FL_U(w) \vee FL_V(w)), D_S(w) \vee (D_U(w) \wedge D_V(w))) : w \in X\}
 \end{aligned}$$

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Now, we have  $[S \cup U] \cap [S \cup V]$

$$\begin{aligned}
 &= \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &\cup \{(w, Tr_U(w), Ind_U(w), FL_U(w), D_U(w)) : w \in X\} \\
 &\sqcap \{(w, Tr_S(w), Ind_S(w), FL_S(w), D_S(w)) : w \in X\} \\
 &\sqcup \{(w, Tr_V(w), Ind_V(w), FL_V(w), D_V(w)) : w \in X\} \\
 &= \{(w, (Tr_S(w) \vee Tr_U(w)), (Ind_S(w) \wedge Ind_U(w)), \\
 &(FL_S(w) \wedge FL_U(w)), (D_S(w) \vee D_U(w)) : w \in X\} \\
 &\sqcap \{(w, (Tr_S(w) \vee Tr_V(w)), (Ind_S(w) \wedge Ind_V(w)), \\
 &(FL_S(w) \wedge FL_V(w)), (D_S(w) \vee D_V(w))\} \\
 &= \{(w, (Tr_S(w) \vee Tr_U(w)) \wedge (Tr_S(w) \vee Tr_V(w)), \\
 &(Ind_S(w) \vee Ind_U(w)) \vee (Ind_S(w) \wedge Ind_V(w)), \\
 &(FL_S(w) \wedge FL_U(w)) \vee (FL_S(w) \wedge FL_V(w)), (D_S(w) \vee D_U(w)) \wedge (D_S(w) \vee D_V(w))\} : w \in X\} \\
 &= \{(w, (Tr_S(w) \vee Tr_U(w)) \wedge Tr_V(w), (Ind_S(w) \wedge Ind_U(w)) \vee Ind_V(w), \\
 &(FL_S(w) \wedge FL_U(w)) \vee FL_V(w), (D_S(w) \vee D_U(w)) \wedge D_V(w)) : w \in X\} \\
 &= S \cup [U \cap V] \\
 &\text{Therefore, } S \cup [U \cap V] = [S \cup U] \cap [S \cup V].
 \end{aligned}$$

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$$\begin{aligned}
 & \text{We have } S \cap [U \cup V] \\
 &= \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\
 & \cap \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\} \\
 & \cup \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}) : w \in X\} \\
 &= \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \cap \\
 & \{ \{(w, Tr_{S(w)} \vee Tr_{V(w)}, Ind_{S(w)} \wedge Ind_{V(w)}, FL_{U(w)} \\
 & \wedge FL_{V(w)}, D_{U(w)} \vee D_{V(w)}) : w \in X\} \} \\
 &= \{(w, (Tr_{S(w)} \wedge Tr_{U(w)}) \vee Tr_{V(w)}, (Ind_{S(w)} \vee Ind_{U(w)}) \wedge Ind_{V(w)}, \\
 & (FL_{S(w)} \vee FL_{U(w)}) \wedge FL_{V(w)}, (D_{S(w)} \wedge D_{U(w)}) \vee D_{V(w)}) : w \in X\}
 \end{aligned}$$

Now, we have  $[S \cap U] \cup [S \cap V]$

$$\begin{aligned}
 &= \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\
 & \cap \{(w, Tr_{U(w)}, Ind_{U(w)}, FL_{U(w)}, D_{U(w)}) : w \in X\} \\
 & \cup \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\
 & \cap \{(w, Tr_{V(w)}, Ind_{V(w)}, FL_{V(w)}, D_{V(w)}) : w \in X\} \\
 &= \{(w, (Tr_{S(w)} \wedge Tr_{U(w)}), (Ind_{S(w)} \vee Ind_{U(w)}), \\
 & (FL_{S(w)} \vee FL_{U(w)}), (D_{S(w)} \wedge D_{U(w)}) : w \in X\} \\
 & \cup \{(w, (Tr_{S(w)} \wedge Tr_{V(w)}), (Ind_{S(w)} \vee Ind_{V(w)}), \\
 & (FL_{S(w)} \vee FL_{V(w)}), (D_{S(w)} \wedge D_{V(w)})\} \\
 &= \{(w, (Tr_{S(w)} \wedge Tr_{U(w)}) \vee (Tr_{S(w)} \wedge Tr_{V(w)}), \\
 & (Ind_{S(w)} \vee Ind_{U(w)}) \wedge (Ind_{S(w)} \vee Ind_{V(w)}), \\
 & (FL_{S(w)} \vee FL_{U(w)}) \wedge (FL_{S(w)} \vee FL_{V(w)}), (D_{S(w)} \wedge D_{U(w)}) \vee (D_{S(w)} \wedge D_{V(w)}) \\
 & : w \in X\} \\
 &= \{(w, Tr_{S(w)} \wedge (Tr_{U(w)} \vee Tr_{V(w)}), Ind_{S(w)} \vee (Ind_{U(w)} \wedge Ind_{V(w)}), \\
 & FL_{S(w)} \vee (FL_{U(w)} \wedge FL_{V(w)}), D_{S(w)} \wedge (M_{U(w)} \vee M_{V(w)}) : w \in X\}
 \end{aligned}$$

$$= S \cap [U \cup V]$$

Therefore,  $S \cap [U \cup V] = [S \cap U] \cup [S \cap V]$ .

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$$\begin{aligned}
 & \text{We have, } S^c = \{(w, 1 - Tr_{S(w)}, 1 - Ind_{S(w)}, 1 - FL_{S(w)}, 1 - D_{S(w)}) : w \in X\}. \\
 & \text{Therefore, } (S^c)^c \\
 &= \{(w, 1 - (1 - Tr_{S(w)}), 1 - (1 - Ind_{S(w)}), 1 - (1 - FL_{S(w)}), 1 - (1 - D_{S(w)})) : w \in X\} \\
 &= \{(w, Tr_{S(w)}, Ind_{S(w)}, FL_{S(w)}, D_{S(w)}) : w \in X\} \\
 &= S \\
 & \text{Hence, } ((S^c)^c) = S.
 \end{aligned}$$

Saaty [ developed the AHP approach, which can compare two alternatives. In this study, we present a novel interval-valued neutrosophic (IVN) AHP technique. A developed rating scale for IVN's analytic heuristic procedure. Figure 1 shows the flowchart of this paper.

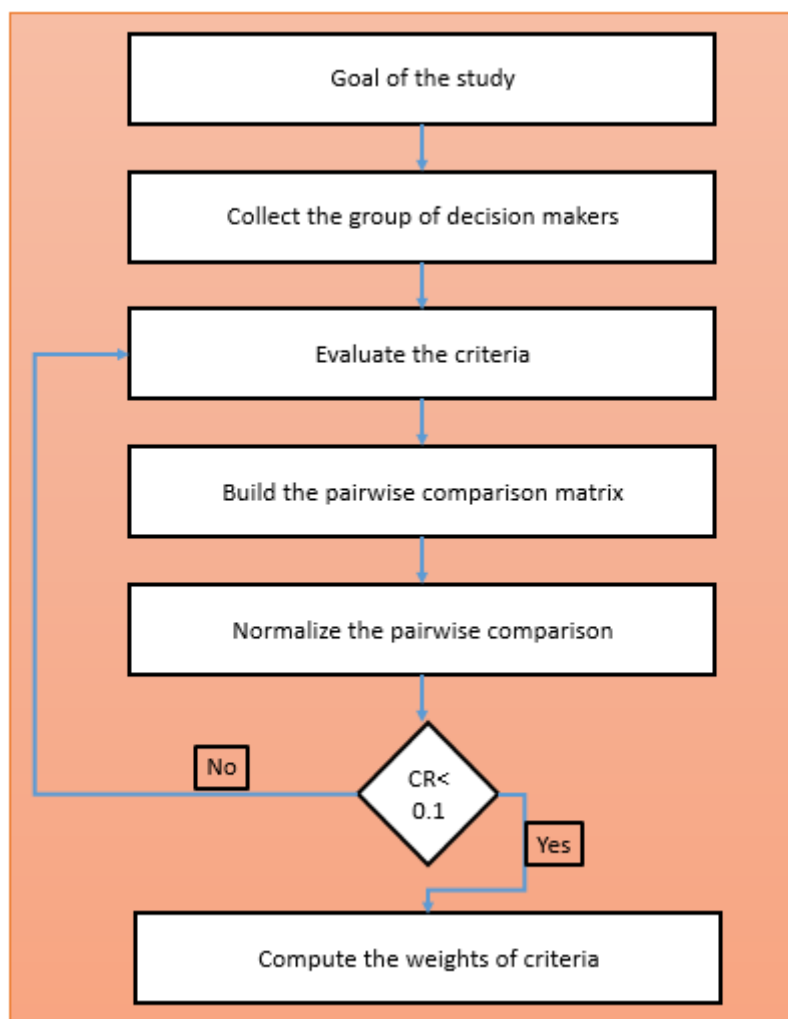


Figure 1: The flowchart of this study.

### 3. Discussion of the research outcomes

The conducted analysis revealed the importance of considering a wide range of factors, including market trends, business requirements, and customer needs, in designing effective curricula. It also highlighted the need for an innovative approach that can adapt to the rapidly-changing nature of the industry. By leveraging the power of Neutrosophic-Operational and Multi-Decision Analysis, educators can develop more comprehensive and effective curricula that prepare students for successful careers in FinTech marketing. This study provides a new direction for research in FinTech marketing education and highlights the potential of Neutrosophic-Operational and Multi-Decision Analysis as a powerful tool for evaluating complex problems in a rapidly-evolving industry. This section applies the N-AHP methodology to a FinTech Marketing course, we simply name it a science course here in this paper. Taking into account the suggested topic, this strategy is applied to the criteria that have been presented and organized into four groups: sustainability, science education, e-learning, and technology. In this case, we use a hybrid strategy, combining the N-AHP/MCDA procedure with the WLC. Table 1 shows the opinions of experts.

Regarding the selection of relevant and diversified factors in SSE scientific e-learning education systems, the verified findings represent the state of the art. As a result, a unique strategy for supporting decisions is laid out that takes into account a wide range of possible outcomes from the perspective of decision-makers. An MCDA niche in SSE may thus fulfill the goal of decision-makers. Sustainability, scientific education, e-learning, and technological factors are among the most important of the chosen criteria.

The selection of factors and sub-factor is the first major step in N-AHP, and it has the potential to provide strong motivation for the evaluation of components essential to the provision of sustainable

scientific e-learning. Features of this operational approach impose constraints on criterion selection, making it crucial to zero in on the best criteria and sub-criteria for this study. The pick was made following deliberation among decision-makers based on empirical evidence gleaned from a vast repository. The criteria are divided into four categories: environmental considerations, scientific instruction, distance education, and technological advancements. Here, these four levels of the hierarchical structure were applied to dilemmas in sustainability science courses taken via online courses.

In the second major stage, the N-AHP method is used to process the values of criterion and sub-criterion worth using the comprehensively selected criteria as a definite out-ranking approach. Within the AHP framework, they ponder the implications and potential for innovation in several elements of long-term, online scientific education. The neutrosophic-logic setup has been engaged to standardize and organize the data on criterion and sub-criteria. A standard ranking system of zero to one was used to assign relative weights to each of the four categories discussed above, with zero representing the least weight and one the greatest. Since these criteria do not share the same level of importance, decision-makers must now draw lines between them using a Pair-wise Comparison Matrix (PCM). Using the Consistency Ratio (CR) matrix, the values of this criterion and sub-criteria may be determined in conjunction with the PCM. To what extent the committed value can be consistently calculated is shown in each matrix. A rule of thumb will apply when the CR value is less than 10%; otherwise, the decision-makers in this scenario will need to reconsider the possible outcomes. The final findings in this experiment gained using the N-AHP/ approach were shown alongside the WLC and hypersensitivity test. The most important requirements of sustainable scientific e-learning educational standards for a longer-lasting education program were generated by the sixteen probable impacts and four categories as the indicator-based model. Then, the most important criteria are derived from the WLC, and the probabilities of the six implementation techniques are analyzed using a risk assessment. Sub-criteria are then evaluated using a specialized online survey. The results have so shown the primary frameworks for dealing with long-term e-learning in the sciences.

The AHP defines the most important requirements for sustainable scientific e-learning systems that include sustainability elements. The ecological sub-criterion is by far the most impacted and influencing of the others. Sustainability has the greatest weight followed by technology than the education of science. E-learning has the least weight in the criteria. Figure 2 shows the weights of the criteria.

Table 1: The pairwise comparison matrix.

criteria	C1	C2	C3	C4
C1	1	0.6	0.6	0.7
C2	1.666667	1	0.2	0.3
C3	1.666667	5	1	0.2
C4	1.428571	3.333333	5	1

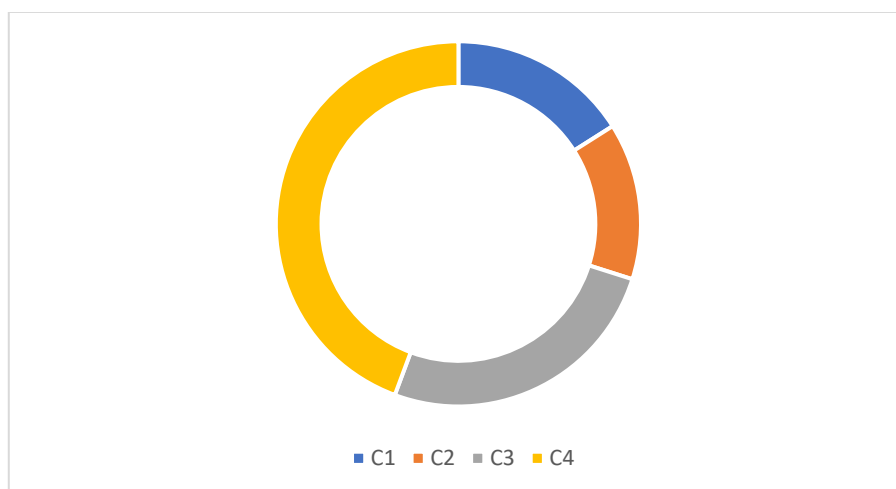


Figure 2: The weights of criteria.

#### 4. Conclusion

The findings present unique evidence on the identification of key criteria for e-learning systems for SSE that might have a substantial effect and influence. This paper addresses a need in MCDA practices and multi-criteria analyses by describing a unique way for decision assistance using a sustainable scientific e-learning school system and probability methodologies. The study's key result was that this technique could reveal the most promising criteria for scientific e-learning systems for lengthy learning programs and prescribe they're starting ranking in an SSE e-learning education system. Thirty-nine professionals were surveyed using a 5 Likert scale to analyze the relative merits of several practices and techniques. The results were used in conjunction with the WLC and scenario analysis to establish the most significant criterion, ranking, and probability. In terms of single-influence analysis, N-AHP yields consistent results regardless of the marker integer used in the evaluation. The appropriateness score of 0.54 in sustainable scientific e-learning educational standards, coupled with program implementation A, was the most important factor. The achieved findings include novel data on the major criterion selection of distinguishing possible effects and influence centered in a typical example for sustainability scientific education. This paper fills a need in MCDA practices and multi-criteria analyses by outlining a novel approach to decision-support based on the sustainable science e-learning school system and probability techniques, with input from expert decision-makers. The primary finding of this study was that the proposed methodology could reveal the most promising criteria for scientific e-learning systems for lengthy learning programs and establish their initial order in a sustainable science e-learning schooling system.

#### References

- [1] R. Lozano, F. J. Lozano, K. Mulder, D. Huisingsh, and T. Waas, "Advancing higher education for sustainable development: international insights and critical reflections," *Journal of Cleaner Production*, vol. 48. Elsevier, pp. 3–9, 2013.
- [2] A. Pereira, A. Q. Mendes, L. Morgado, L. Amante, and J. Bidarra, "Universidade Aberta's pedagogical model for distance education: a university for the future." Universidade Aberta, 2008.
- [3] J. S. Jeong and D. González-Gómez, "A web-based tool framing a collective method for optimizing the location of a renewable energy facility and its possible application to sustainable STEM education," *Journal of Cleaner Production*, vol. 251, p. 119747, 2020.
- [4] R. Lozano and W. Young, "Assessing sustainability in university curricula: exploring the influence of student numbers and course credits," *Journal of cleaner production*, vol. 49, pp. 134–141, 2013.
- [5] D. Y. Shee and Y.-S. Wang, "Multi-criteria evaluation of the web-based e-learning system: A methodology based on learner satisfaction and its applications," *Computers & Education*, vol. 50, no. 3, pp. 894–905, 2008.
- [6] C. Eneroth, "E-learning for the environment: Improving e-learning as a tool for cleaner production education," 2000.
- [7] S. Wan and J. Dong, *Decision-making theories and methods based on interval-valued intuitionistic fuzzy sets*. Springer Nature, 2020.
- [8] D. E. Hansen, "Knowledge transfer in online learning environments," *Journal of Marketing Education*, vol. 30, no. 2, pp. 93–105, 2008.
- [9] R. M. Schramm, R. J. Wagner, and J. M. Werner, *Student perceptions of the effectiveness of web-based courses*. Magna Publications Madison, WI, USA, 2001.
- [10] M. Paechter, B. Maier, and D. Macher, "Students' expectations of, and experiences in e-learning: Their relation to learning achievements and course satisfaction," *Computers & Education*, vol. 54, no. 1, pp. 222–229, 2010.
- [11] W. Lambrechts, W. T. Paul, A. Jacques, H. Walravens, L. Van Liedekerke, and P. Van Petegem, "Sustainability segmentation of business students: Toward self-regulated development of critical and interpretational competencies in a post-truth era," *Journal of cleaner production*, vol. 202, pp. 561–570, 2018.
- [12] R. Garrison, "Theoretical challenges for distance education in the 21st century: A shift from structural to transactional issues," *International Review of Research in Open and Distributed Learning*, vol. 1, no. 1, pp. 1–17, 2000.
- [13] J. Nowotny *et al.*, "Towards global sustainability: Education on environmentally clean energy technologies," *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 2541–2551, 2018.
- [14] M. Pavlova, "Teaching and learning for sustainable development: ESD research in technology education," *International Journal of Technology and design education*, vol. 23, no. 3, pp. 733–748, 2013.
- [15] D. Gonzalez-Gomez, J. S. Jeong, and F. Cañada-Cañada, "Enhancing science self-efficacy and attitudes

- of Pre-Service Teachers (PST) through a flipped classroom learning environment,” *Interactive Learning Environments*, vol. 30, no. 5, pp. 896–907, 2022.
- [16] J. Mezirow, “Transformative learning: Theory to practice,” *New directions for adult and continuing education*, vol. 1997, no. 74, pp. 5–12, 1997.
- [17] Z. Fadeeva and Y. Mochizuki, “Higher education for today and tomorrow: university appraisal for diversity, innovation and change towards sustainable development,” *Sustainability Science*, vol. 5, no. 2, pp. 249–256, 2010.
- [18] W. Leal Filho *et al.*, “The role of transformation in learning and education for sustainability,” *Journal of cleaner production*, vol. 199, pp. 286–295, 2018.
- [19] B. Esmailian, M. Rust, P. K. Gopalakrishnan, and S. Behdad, “Use of citizen science to improve the student experience in engineering design, manufacturing, and sustainability education,” *Procedia Manufacturing*, vol. 26, pp. 1361–1368, 2018.
- [20] J. S. Jeong, L. García-Moruno, and J. Hernández-Blanco, “A site planning approach for rural buildings into a landscape using a spatial multi-criteria decision analysis methodology,” *Land Use Policy*, vol. 32, pp. 108–118, 2013.
- [21] M. Zare *et al.*, “Multi-criteria decision-making approach in E-learning: A systematic review and classification,” *Applied Soft Computing*, vol. 45, pp. 108–128, 2016.
- [22] D. Jain, R. Garg, and A. Bansal, “A parameterized selection and evaluation of e-learning websites using topsis method,” *International Journal of Research & Development in*, vol. 22, no. 3, pp. 12–26, 2015.
- [23] E. Islas-Pérez, Y. H. Pérez, M. Pérez-Ramírez, C. F. García-Hernández, and B. Zayas-Pérez, “Multicriteria Decision Making for Evaluation of e-Learning Tools,” *Res. Comput. Sci.*, vol. 106, pp. 27–37, 2015.
- [24] F. Smarandache and S. Pramanik, *New trends in neutrosophic theory and applications*, vol. 1. Infinite Study, 2016.
- [25] H. ElGhawalby and A. A. Salama, “Ultra neutrosophic crisp sets and relations,” *Florentin Smarandache, Surapati Pramanik*, p. 395, 2015.
- [26] S. A. Alblowi, A. A. Salama, and M. Eisa, *New concepts of neutrosophic sets*. Infinite Study, 2014.
- [27] F. Smarandache, “A unifying field in logics. neutrosophy: Neutrosophic probability, set, and logic.” American Research Press, Rehoboth, 1999.