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Evaluation of the challenges and opportunities of Artificial Intelligence applied in current Latin American Education with the help of Neutrosophic SWOT and Neutrosophic Cognitive Maps

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Abstract. Artificial intelligence (AI) has revolutionized many areas, including education, by improving teaching methods and addressing challenges such as equity of access, data privacy, quality of algorithms, and adaptation of traditional education systems. This paper aims to analyze and understand the challenges and opportunities of artificial intelligence in Latin American education today. For the proposed evaluation we use the criteria of five experts on the subject. Specifically, we use Neutrosophic SWOT and static analysis of Neutrosophic Cognitive Maps techniques. The use of tools in the field of Neutrosophy allows us to incorporate indeterminacy into the calculations carried out, which allows greater accuracy in the results. Indeterminacy is an intrinsic component of decision-making.

Keywords: Artificial Intelligence, Education, Neutrosophic SWOT, Neutrosophic Cognitive Map, Static Analysis, Neutrosophic Number, Single-Valued Triangular Neutrosophic Number, Neutrosophic Graph.

1 Introduction

Artificial Intelligence (AI) impacts society, education is no exception. In recent decades, the accelerated advancement in AI technologies has allowed the development of tools and systems that promise to revolutionize learning and teaching methods. However, integrating AI into education presents challenges that must be addressed to increase its benefits and reduce risks.

The main challenge of AI is to guarantee equitable access to these technologies in education. Socioeconomic differences between students can be amplified if AI tools are not equitably available, which could exacerbate preexisting educational gaps. Data must be private and secure because the educational AI system often requires collecting and analyzing extensive personal data from students.

The objective of this article is to evaluate the use of AI in higher education in any Latin American country, determining its benefits and deficiencies for both, students and teachers. The algorithms used in training can make unfair or discriminatory decisions, affecting and generating distrust between educators and students, which is another great challenge.

Adapting traditional educational systems to new AI technologies requires a profound restructuring. Educators need ongoing training to effectively use these tools, and curricula must be updated to include essential digital competencies. This adaptation process must also consider technology and the preservation of human interactions fundamental to learning equitably.

Addressing challenges proactively and thoughtfully mitigates the risks associated with AI in education. The potential to generate more inclusive, personalized, and effective learning environments must also be harnessed.

To carry out the measurement we propose to use a series of decision-making tools adapted to the framework of neutrosophy. According to F. Smarandache, Neutrosophy is the branch of philosophy dedicated to the study of neutralities, which includes the neutral, unknown, incoherent, inconsistent, contradictory, and paradoxical, among others [1]. That is why with the incorporation of neutrosophic knowledge we can include knowledge of which there is no partial or total certainty because it is indeterminate and therefore the results of the studies carried out are more reliable to reality.

One of these tools is the Neutrosophic SWOT (Strengths, Weaknesses, Opportunities, and Threats) method [2-4]. The application of this technique allows us to quantify the Challenges and Opportunities of applying AI in education in the current era. The second step is the determination of the causal relationship between the identified concepts, in this way, neutrosophic graphs will be designed [5].

A neutrosophic graph is a graph where at least one of the edges is considered indeterminate. That is, it cannot be determined in the case of two vertices if there is an edge that joins them and this is represented graphically with the help of dashed lines.

Finally, these relationships are represented in Neutrosophic Cognitive Maps (NCM) [6-11]. These are neutrosophic graphs whose edges have associated numerical weight values and where indeterminate edges are symbolically represented by I to indicate indeterminacy. A static analysis of the NCM is used for the calculations. The indices associated with this type of Cognitive Map will allow us to determine and measure the importance of each of the factors or concepts determined to be important in this study.

The structure of this paper is a Preliminaries section where the basic notions of Neutrosophy, Neutrosophic SWOT, and Neutrosophic Cognitive Maps theories are explained. The Results section contains the results obtained from the evaluations given by the experts. At the end, the conclusions are given.

2 Preliminaries

2.1 SWOT analysis

SWOT analysis is a methodology for studying the situation of a company or a project, analyzing its internal characteristics (Weaknesses and Strengths) and its external situation (Threats and Opportunities) in a [2-4].

This analysis is carried out in four stages:

- External analysis,
- Internal analysis,
- Preparation of the SWOT matrix,
- Determination of the strategy to use.

The organization depends on the environment around it for its existence. This framework has opportunities and threats for the organization. These are the elements that are assessed in the external analysis. The organization excels in some areas but has room for growth in others. The outcome of these matters relies on the management of the organization, these are the strengths and weaknesses. The organization's growth can be affected positively or negatively by these four factors.

When utilized, opportunities can be beneficial aspects of the environment, aiding in the advancement and prosperity of an organization or project. Threats come from outside and can harm the organization or project. These problems can be a danger to the organization or the project. We need to come up with plans to solve them. Weaknesses within an organization or project are areas that require improvement and are within the control of its fundamental components. Meanwhile, strengths are good components that are the opposite of weaknesses. We should use them and make them even better.

During the SWOT analysis, we look at what our company is good at (strengths) and what we need to work on (weaknesses). This encompasses our assets, employees, merchandise, and public perception. This is why looking inside the organization helps us figure out how much and how good the resources and processes are, and whether the organization can control them.

The four parts of the analysis are put in a chart and looked at by professionals. These results are combined using the percentages of their ratings. During the assessment, we consider the strengths and areas for growth to determine the most effective strategies for supporting the organization or project.

These positive actions can be held back by joining weaknesses with threats. We should always remember this combination because it prevents the organization from moving excessively fast. The organization should consider both the positive and negative potential outcomes and devise a strategic plan for the future. Thus, potential is measured using Strengths + Opportunities, Risk = Strength + Threats, Challenges = Weaknesses + Opportunities, and Limitations = Weaknesses + Threats.

Especially in the Neutrosophic SWOT, Neutrosophy-based assessment tools are used.

2.2 Neutrosophic Cognitive Maps

Definition 1: ([5]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \to \,]^{-}0, 1^{+}[$, which satisfy the condition $^{-}0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^{+}$ for all $x \in X$. $u_A(x), r_A(x)$, and $v_A(x)$ denote the membership functions of truthfulness, indeterminacy, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

NS is useful only as a philosophical approach, so *a Single-Valued Neutrosophic Set* is defined to guarantee the applicability of neutrosophy, see Definition 2.

Definition 2: ([5]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$, and $v_A(x)$ denote the membership functions of truthfulness, indeterminacy, and falseness of x in A, respectively. For convenience, a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfies $0 \leq a + b + c \leq 3$.

Neutrosophic Logic (NL) extends fuzzy logic. A proposition P is characterized by three components; see [5, 12-13]:

$$NL(P) = (T,I,F) \quad (2)$$

Where component T is the degree of truthfulness, F is the degree of falsity and I is the degree of indeterminacy. T, I, and F belong to the interval [0, 1], and they are independent of each other.

A *neutrosophic number* is formed by the algebraic structure a+bI, where I = indeterminacy. In the following, we formally describe some important concepts.

Definition 3: ([14]) Let R be a ring. The *neutrosophic ring* $\langle R \cup I\rangle$ is also a ring, generated by R and I under the operation of R, where I is a neutrosophic element that satisfies the property $I^2 = I$. Given an integer n, then, n+I and nI are neutrosophic elements of $\langle R \cup I\rangle$, and in addition $0 \cdot I = 0$. Also, I^{-1}, the inverse of I is not defined.

E.g., a neutrosophic ring is $\langle \mathbb{Q} \cup I\rangle$ generated by $\mathbb{Q}$, which is the set of rationals.

Some operations using I are $I + I + \ldots + I = nI$.

Definition 4: ([14]) A *neutrosophic number* N is also defined as a number as follows:

$$N = d + I \quad (3)$$

Where d is the *determined part* and I is the *indeterminate part* of N.

Let $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ be two neutrosophic numbers, then some operations between them are:

1. $N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition),
2. $N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),
3. $N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),
4. $\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

A *neutrosophic matrix* is a matrix whose components are elements of $\langle R \cup I\rangle$.

Thus, it is possible to generalize the operations between vectors and matrices on R to the ring $\langle R \cup I\rangle$.

A *neutrosophic graph* is a graph with at least one neutrosophic edge linking two nodes, that is to say, there is an edge with an indeterminacy on its two nodes connection, [5], see Figure 1.

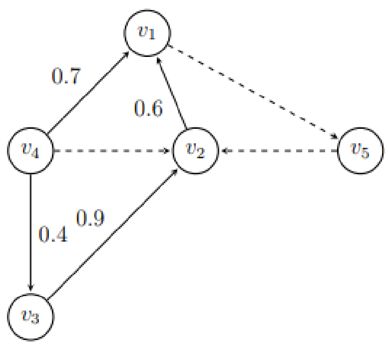

Figure 1: Example of neutrosophic graph. Source [5].

The des-neutrosophication process was introduced by Salmeron and Smarandache [15], which converts a neutrosophic number into one numerical value. This process provides a range of numbers for centrality using as a base the maximum and minimum values of $I = [a_1, a_2] \subseteq [0, 1]$, based on Equation 4:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (4)$$

Each node constitutes a causal concept. This characteristic makes the representation flexible to visualize human knowledge. The adjacency matrix is obtained from the values assigned to the arcs.

The values obtained by the group of experts involved in the process are aggregated, conforming to the general knowledge of the relationships between the criteria. Activity results in the NCM [5]. From the assessment of the causal relationships, the static analysis is performed. The knowledge stored in the adjacency matrix is taken as a reference. For the development of the present method, we work with the *indegree (id)* of output as shown by Equation 5, [5].

$$id_i = \sum_{j=1}^{n} \left| I_{ij} \right| \quad (5)$$

The *outdegree* (*od*) is calculated by Equation 6, and the total degree (*td*) by Equation 7:

$$od_i = \sum_{j=1}^{n} \left| I_{ji} \right| \quad (6)$$

$$td_i = id_i + od_i \quad (7)$$

Definition 5 ([16, 17]): The Single-Valued Triangular Neutrosophic Number, $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsity membership functions are defined as follows:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}\left(\frac{x-a_1}{a_2-a_1}\right), a_1 \le x \le a_2} \\ \alpha_{\tilde{a}, x=a_2} \\ \alpha_{\tilde{a}\left(\frac{a_3-x}{a_3-a_2}\right), a_2 < x \le a_3} \\ 0, \text{otherwise} \end{cases} \quad (8)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \le x \le a_2 \\ \beta_{\tilde{a},} \ x = a_2 \\ \frac{(x - a_2 + \beta_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, \ a_2 < x \le a_3 \\ 1, \text{otherwise} \end{cases} \quad (9)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \le x \le a_2 \\ \gamma_{\tilde{a},} x = a_2 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, \ a_2 < x \le a_3 \\ 1, \text{otherwise} \end{cases} \quad (10)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$,$a_1, \ a_2, a_3 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3$.

Definition 6 ([16, 17]): Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued triangular neutrosophic numbers and λ is any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
3. Inversion: $\tilde{a}^{-1} = \langle (a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
4. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda < 0 \end{cases}$$
5. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 > 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$
6. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, \ a_3 > 0 \text{ and } b_3 > 0 \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

Where, ∧ is a t-norm and ∨ is a t-conorm.

3 Results

The factors that influence the use of AI in Latin American classrooms were determined. These are the following:

1. AI develops new skills in students,
2. The use of these technologies must be balanced with other pedagogical practices that are traditional and effective,
3. There is no adequate literacy, teacher training, and government regulations for the use of AI in classrooms,
4. There is no ethical and multidisciplinary approach to teaching with AI,
5. There are no periodic updates to the technology nor it is done for personal and environmental benefit.
6. International collaboration is not encouraged nor there is an investment in AI talent,
7. There are flaws in the privacy and security of personal data,
8. AI is truly capable of transforming the teaching and learning process in education, through sophisticated studies, personalized tutoring, chatbots, and other tools,
9. AI in education causes benefits of adaptive courses on student performance and motivation,
10. AI improves educational quality and reduces teachers' workload,
11. AI is used in assessments to improve performance prediction, the use of educational robots, and the transparency of assessments,
12. Technology meets the objective of optimizing teaching, personalizing learning, conducting effective evaluations, and improving educational administration,
13. AI generates new knowledge,
14. There is inequality in capturing the benefits of these tools, due to the social and economic inequality of students,
15. To implement these technologies, high-quality data is needed and there are difficulties in customizing the algorithms,
16. There is the problem of interpretation and bias in the results that AI gives,
17. Teachers do not have computer tools, cutting-edge technology, and training in educational institutions, which makes it difficult to use AI as a teaching strategy in classrooms.
18. Educators must be continuously trained in the use of these tools.
19. Human interaction can be neglected when these technologies are used continuously.

The previous aspects were classified into Strengths, Weaknesses, Opportunities, and Threats as indicated below according to the number with which we have listed them previously:

Strengths: 1, 2;
Weaknesses: 3, 4, 5, 6, 7;
Opportunities: 8, 9, 10, 11, 12, 13;
Threats: 14, 15, 16, 17, 18, 19.

Five experts were selected to carry out the evaluations according to the scale that appears in Table 1.

Table 1. Linguistic terms for evaluations and their associated SVTNNs. See [18].

Linguistic Terms	SVTNN
Very low (VL)	$\langle(0,0,1); 0.00, 1.00, 1.00\rangle$
Low (L)	$\langle(0,1,3); 0.17, 0.85, 0.83\rangle$
Medium Low (MDL)	$\langle(1,3,5); 0.33, 0.75, 0.67\rangle$
Medium (M)	$\langle(3,5,7); 0.50, 0.50, 0.50\rangle$
Medium High (MDH)	$\langle(5,7,9); 0.67, 0.25, 0.33\rangle$
High (H)	$\langle(7,9,10); 0.83, 0.15, 0.17\rangle$
Very High (VH)	$\langle(9,10,10); 0.00, 1.00, 1.00\rangle$

To reach a conjoint evaluation of all the experts, they were asked to agree on an evaluation for each of the possible combinations between an internal factor and an external one. This implied the need for deliberation among the specialists, who in the end arrived at the requested results.

Table 2. SWOT neutrosophic matrix obtained from the criteria of the five specialists.

		Strengths		Weaknesses				
		S1	**S2**	**W1**	**W2**	**W3**	**W4**	**W5**
Opportunities	**O1**	VH	MDH	M	MDH	MDH	MDH	MDH
	O2	VH	M	M	MDH	MDH	MDH	MDH
	O3	H	M	MDH	L	H	M	M
	O4	VH	M	M	H	H	MDH	MDL
	O5	VH	M	M	H	MDH	M	MDL
	O6	H	M	M	L	M	MDH	MDH
Threats	**T1**	M	MDH	VL	L	MDL	L	L
	T2	MDL	MDL	L	H	MDL	L	L
	T3	L	VH	L	L	L	M	L
	T4	L	VH	L	H	L	L	L
	T5	MDH	MDH	L	MDL	MDL	L	L
	T6	L	VH	H	VL	L	MDH	M

The data in Table 2 are processed for each quadrant by finding the average of the results of the quadrant using the algebra between SVTNNs, the results are summarized in Table 3.

Table 3. Aggregation of the results of Table 2 for each quadrant using the average of the SVTNNs.

	Strengths	**Weaknesses**
Opportunities	$\langle(5.8333, 7.5, 8.6667); 0.67, 0.25, 0.33\rangle$	$\langle(4.0667, 6.0000, 7.8667); 0.17, 0.85, 0.83\rangle$
Threats	$\langle(3.9167, 5.4167, 6.9167); 0.17, 0.85, 0.83\rangle$	$\langle(1.2, 2.4667, 4.3); 0.00, 1.00, 1.00\rangle$

To have a crisp score value between 0 and 10 for each of the quadrants, we have the following accuracy function equation:

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (11)$$

So, we have:
For the SW quadrant: 7.5625,
ST Quadrant: 4.3672,
WO Quadrant: 4.8196,
WT: 1.9917.

From here it can be concluded that the potential = SO is 7.5625 on a scale of 10.
However, risk and challenge are rated at 4.3672 and 4.8196, respectively, which is less than average.
While the evaluation of the limitations is low, equal to 1.9917. This means that there are major limitations.
Now we will study the problem from the perspective of the dynamics between the variables, using the Neutrosophic Cognitive Maps through a static analysis.
We will represent this using the adjacency matrix that appears in Tables 4-5.

Table 4. Neutrosophic Cognitive Map Matrix according to experts.

Variable	1	2	3	4	5	6	7	8	9	10
1	0	I	I	0	0	0.1	0.1	0.9	0.9	0.7
2	I	0	I	0.9	0	0	0	0.6	0	0.5
3	I	I	0	0.8	I	1	0	0.1	0	0.9
4	0	0.8	0.7	0	0	0.7	0	0.7	0.5	0.9
5	0	0	I	0	0	I	1	0.1	0.1	0.2
6	0.1	0	1	0.6	I	0	0.6	0.8	0.6	0.7
7	0.1	0	0	0	1	0.7	0	0.6	0.4	0.6
8	0.9	0.7	0.2	0.8	0.1	0.7	0.5	0	1	1
9	0.9	0	0	0.5	0.1	0.7	0.4	1	0	1
10	0.7	0.5	0.8	0.9	0.2	0.7	0.7	1	1	0
11	0.9	0.6	0.5	0.9	0.8	0.4	0.9	1	1	1
12	0.9	0.5	0.4	0.6	0.4	0.4	0.6	1	1	1
13	0.9	0.7	0.6	0.6	0.6	0.8	0	0.8	1	1
14	0.9	0.5	0.7	0	1	0.6	0	0.8	0	0
15	0.4	0.6	0	0.2	0.6	0.7	1	0.6	0.7	0.8
16	0.2	0	0.6	0	0.8	0.7	1	0.9	0.7	0.9
17	0.3	0.3	1	0	0.6	1	1	0.9	0.8	0.8
18	0.4	0	1	1	0.8	1	1	0.9	0.9	0.8
19	0	0	0.7	1	0	0	I	0	0	I

Table 5. Neutrosophic Cognitive Map Matrix according to experts (Continued).

Variable	11	12	13	14	15	16	17	18	19
1	0.9	0.9	0.9	0.9	0.5	0.1	0.4	0.4	0
2	0.6	0.5	0.6	0.7	0.5	0.7	0	0.3	0
3	0.6	0.3	0.7	0.6	0	0.7	1	1	0.8
4	0.9	0.7	0.6	0	0.3	0	0	1	1
5	0.8	0.4	0.6	1	0.6	0.8	0.6	0.8	0
6	0.4	0.3	0.9	0.7	0.8	0.8	1	1	0
7	0.9	0.6	0	0	1	1	1	1	I
8	1	1	0.9	0.7	0.6	0.9	0.9	0.9	0
9	1	1	1	0	0.7	0.8	0.9	0.9	0
10	1	1	1	0	0.9	0.9	0.7	0.7	I
11	0	1	1	I	1	0.8	0.8	0.9	0.9
12	1	0	1	0.9	0.8	1	0.6	0.9	0
13	1	1	0	0.8	0.8	1	0.7	0.8	0
14	I	0.9	0.8	0	0	1	0	I	0
15	1	0.9	0.8	0	0	0.8	1	1	0
16	0.7	1	1	1	0.8	0	0	0	0
17	0.8	0.6	0.7	0	1	0	0	1	0
18	0.9	0.8	0.7	I	1	0	1	0	0
19	0.9	0	0	0	0	0	0	0	0

The results presented in the two previous tables correspond to the consensus of the five experts in evaluating the strength of the relationship between two variables or concepts on a scale between 0 and 1. Furthermore, it is possible to associate a weight symbolically represented as I when the relationship between the concepts is not known or there is a disagreement between the evaluations given by the experts.

To help the specialists, they were asked to evaluate on a scale from 0 to 10 or I, and then the numerical values obtained were divided by 10.

Table 6 summarizes the results of the static analysis of the variables.

Table 6. Indegree, Outdegree, Total Degree, and Total Degree des-neutrosophied were calculated from the studied variables.

Variable	Indegree	Outdegree	Total Degree	Total Degree des-neutrosophied
1	7.7 + 2I	7.6 + 2I	15.3 + 4I	17.3
2	5.9 + 2I	5.2 + 2I	11.1 + 4I	13.1
3	8.5 + 3I	8.2 + 3I	16.7 + 6I	19.7
4	8.8	8.8	17.6	17.6
5	7 + 2I	7 + 2I	14 + 4I	16
6	10.3 + I	10.2 + I	20.5 + 2I	21.5
7	8.9 + I	8.8 + I	17.7 + 2I	18.7
8	12.8	12.7	25.5	25.5
9	10.9	10.6	21.5	21.5
10	12.7 + I	12.8 + I	25.5 + 2I	26.5
11	14.4 + I	14.4 + I	28.8 + 2I	29.8
12	13	12.9	25.9	25.9
13	13.1	13.2	26.3	26.3
14	7.2 + 2I	7.3 + 2I	14.5 + 4I	16.5
15	11.1	11.3	22.4	22.4
16	10.3	11.3	21.6	21.6
17	10.8	10.6	21.4	21.4
18	12.2 + I	12.6 + I	24.8 + 2I	25.8
19	2.6 + 2I	2.7 + 2I	5.3 + 4I	7.3

Table 6 shows that the order of influence of the variables studied can be summarized as follows according to the Total Degree des-neutrosophied:

$v_{19} \prec v_2 \prec v_5 \prec v_{14} \prec v_1 \prec v_4 \prec v_7 \prec v_3 \prec v_{17} \prec v_6 \approx v_9 \prec v_{16} \prec v_{15} \prec v_8 \prec v_{18} \prec v_{12} \prec v_{13} \prec v_{10} \prec v_{11}$.

4 Conclusion

The use of Artificial Intelligence in daily life is a fact that cannot be denied. This has advantages and disadvantages. However, the advantages can be profited in its application in teaching. The disadvantages are a challenge that must be dealt with. This article studies the pros and cons of using these technologies in a Latin American country today. To do this, we use neutrosophic tools that allow us to include indeterminacy within the study, and this makes the study more complete. Specifically, we used the evaluation of five experts for the use of two techniques, the Neutrosophic SWOT and the static analysis of the Neutrosophic Cognitive Maps. Nineteen variables were determined to be important. It was concluded that the potential is promising. However, the risks and challenges are both medium and the limitations that exist are high. On the other hand, the most important variables to take into account according to the Neutrosophic Cognitive Map are the potential that includes the improvement of the quality of education, the generation of new knowledge, and the support it provides to teachers for teaching. Therefore, it is estimated that there is a positive balance in the potential offered by its application concerning the limitations, risks, and challenges.

5 References

[1] Smarandache, F. (1999) A Unifying Field in Logics: Neutrosophic Logic, Neutrosophy, Neutrosophic Set, Neutrosophic Probability. American Research Press, Rehoboth, NM.

[2] Uztürk, D., and Büyüközkan, G. (2023). Strategic Analysis for Advancing Smart Agriculture with the Analytic SWOT/PESTLE Framework: A Case for Turkey. Agriculture, 13, 2275.

[3] Nabeeh, N. (2023) "Assessment and Contrast the Sustainable Growth of Various Road Transport Systems using Intelligent Neutrosophic Multi-Criteria Decision-Making Model", Sustainable Machine Intelligence Journal, 2, pp. (2):1–12. doi:10.61185/SMIJ.2023.22102.

[4] Batista-Hernández, N., Leyva-Vázquez, M. Y., González-Caballero, E., Valencia-Cruzaty, L. E.., Ortega-Chávez, W., and Smarandache, F. (2021). A new method to assess entrepreneurship competence in university students using based on plithogenic numbers and SWOT analysis. International Journal of Fuzzy Logic and Intelligent Systems, 21, 280-292.

[5] Leyva-Váquez, M.Y. (2018) Neutrosofía: Nuevos Avances en el Tratamiento de la Incertidumbre (In Spanish). Pons, Brussels.

[6] Zafar, A., and Wajid, M. A. (2019). Neutrosophic Cognitive Maps for Situation Analysis. Neutrosophic Sets and Systems, 29, 78-89.

[7] Palacios, A. J. P., Estupiñán-Ricardo, J., Piza, I. A. C., and Herrería, M. E. E. (2021). Phenomenological hermeneutical method and neutrosophic cognitive maps in the causal analysis of transgressions against the homeless. Neutrosophic sets and systems, 44, 147-156.

[8] Pramanik, S., and Chackrabarti, S. N. (2013). A study on problems of construction workers in West Bengal based on neutrosophic cognitive maps. International Journal of Innovative Research in Science, Engineering and Technology, 2, 6387-6394.

[9] C., D. Diego, T. P., D. (2022). Analyzing the impact of social factors on homelessness with neutrosophic cognitive maps. Journal of International Journal of Neutrosophic Science, 19(1), 260-266.

[10] Wajid, M. S., Terashima-Marin, H., Rad, P. N. P., and Wajid, M. A. (2022). Violence Detection Approach based on Cloud Data and Neutrosophic Cognitive Maps. Journal of Cloud Computing, 11, 85.

[11] Al-subhi, S. H., Papageorgiou, E. I., Pérez, P. P., Mahdi, G. S. S., and Acuña, L. A. (2021). Triangular neutrosophic cognitive map for multistage sequential decision-making problems. International Journal of Fuzzy Systems, 23, 657-679.

[12] Christianto, V., Boyd, R. N., and Smarandache, F. (2020). Three possible applications of Neutrosophic Logic in Fundamental and Applied Sciences. International Journal of Neutrosophic Science, 1, 90-95.

[13] Mandour, S. (2023). An Exhaustive Review of Neutrosophic Logic in Addressing Image Processing Issues. Neutrosophic Systems With Applications, 12, 36-55. https://doi.org/10.61356/j.nswa.2023.110.

[14] Abodala, N. (2021). Foundations of Neutrosophic Number Theory. Neutrosophic Sets and Systems, 39, 120-132.

[15] De-la-Rosa, C. B., Bolaños, B. C., Echeverría, H. C., Padilla, R. C., and Ruilova, G. S. (2019). PESTEL analysis with neutrosophic cognitive maps to determine the factors that affect rural sustainability. Case Study of the South-Eastern plain of the province of Pinar del Río. Infinite Study.

[16] Yang, W., Cai, L., Edalatpanah, S. A., and Smarandache, F. (2020). Triangular single valued neutrosophic data envelopment analysis: application to hospital performance measurement. Symmetry, 12, 588.

[17] Dhouib, S. (2021). Optimization of travelling salesman problem on single valued triangular neutrosophic number using dhouib-matrix-TSP1 heuristic. International Journal of Engineering, 34, 2642-2647.

[18] Mathew, L. P., and Sebastian, L. (2023, June). An introduction to single valued neutrosophic fuzzy numbers, trapezoidal single valued neutrosophic fuzzy numbers and triangular single valued neutrosophic fuzzy numbers. In AIP Conference Proceedings (Vol. 2875, No. 1). AIP Publishing.

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