



Intercultural Education from Ancestral Logic: Application of the Ayni Method Multi-Neutrosophic to Strengthen Mixed Methodology in the Waorani Community

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Abstract. Research aimed at determining the Ayni method Multi -Neutrosophic by which a successful blended learning experience enhances multicultural education respecting Ancestral Logic of the Waoranis to create a hybridization of Ancestral Logic and institutional and classroom learning to preserve their cultural identity. A qualitative descriptive-legal research approach was utilized. The results of the documentary analysis included requirements from Ecuador (Constitution, ILO Convention 169) and semi-structured interviews with Waorani leaders and teachers, Triangulation through participant observation of the educational activities taught in the Waorani community. The Ayni method Multi -Neutrosophic was cultural reciprocity and neutrality established through indeterminacies in the blended Ancestral teachings and contemporary classrooms. The conclusion of the study revealed that such a blended experience sustained by the Ayni method Multi -Neutrosophic allows for many blended activities to be taught by the older Waorani and courses focusing on ecology and traditional medicine to strengthen cultural identity and expectations of the national educational curriculum. However, remaining challenges include instructors without proper training and access to all materials. Ultimately, this determination ensures a diverse, culturally responsive classroom experience attainable—even replicable—by other Indigenous populations given trained teachers and restructured materials fostering autonomy while maintaining socio-cultural integrity for the Waorani community.

Keywords: Intercultural Education, Mixed Methodology, Waorani Community, Ancestral Logic, Ayni Multi -Neutrosophic, Cultural Identity, Cultural Preservation.

1. Introduction

Intercultural education in indigenous communities, such as the Waorani in the Ecuadorian Amazon, faces the challenge of integrating ancestral knowledge with formal education systems, a problem that limits access to culturally relevant education that respects their worldview. Despite progress in recognizing the right to intercultural bilingual education (IBE) in the Ecuadorian Constitution and international treaties, educational policies do not always manage to adapt to the specific needs of these communities. The Waorani community, with its rich tradition based on reciprocity and connection with nature, requires an educational model that balances traditional knowledge with national academic standards. The lack of teacher training in interculturality and the scarcity of economic resources hinder

the implementation of methodologies that respect cultural identity [1]. This study addresses this problem by proposing the use of the Ayni method. Multi -Neutrosophic, an approach that models ancestral reciprocity to integrate diverse knowledge. The problem lies in how to design an educational system that not only meets national standards, but also preserves the ancestral Waorani logic. The research focuses on evaluating how a blended teaching methodology can overcome these barriers, promoting inclusive education. This approach responds to the need to guarantee the right to education without compromising cultural identity [2]. The Waorani community represents a paradigmatic case to explore innovative solutions in indigenous contexts. The central question is: how can the Ayni method Multi -Neutrosophic Strengthen intercultural education in this community?

Previous research has addressed intercultural education in Indigenous contexts, highlighting its importance for cultural preservation. For example, Espinoza Freire and Leyva (2020) analyzed the limitations of educational systems in Ecuador, noting that a lack of teacher training and adequate materials hinders the implementation of IBE [1]. In Colombia, the Pedagogy of Mother Earth program has shown that including ancestral knowledge in the curriculum improves school retention [3]. However, these studies do not address how to integrate the specific ancestral logic of communities such as the Waorani. Other works, such as those by Rivera-Mateos et al. (2021), have emphasized the need for participatory methodologies that involve communities in curriculum design [4]. In Venezuela, the Comprehensive Community Education Project (PEIC) has shown positive results in promoting community participation [5]. However, this research lacks an approach that models the cultural contradictions inherent in the integration of knowledge. The literature also points out that formal education systems tend to impose Western pedagogies, marginalizing indigenous knowledge [6]. These gaps highlight the need for innovative approaches that respect the indigenous worldview. In the Waorani case, the lack of specific studies on their ancestral logic leaves a void that this paper seeks to fill [7]. The background review underlines the importance of mixed methodologies adapted to specific cultural contexts.

The relevance of this study lies in its focus on the Waorani community, an indigenous people whose cultural identity is deeply rooted in practices of reciprocity and connection with the Amazonian environment. Intercultural education is not only a right enshrined in the Ecuadorian Constitution (Art. 26, 27, 57, 347) and ILO Convention 169, but also a tool to promote social justice and equity [2]. However, the implementation of educational policies in indigenous communities faces obstacles such as lack of funding and poor teacher training [8]. This work proposes an innovative solution by integrating the Ayni method Multi -Neutrosophic, which allows for the modeling of cultural reciprocity in order to design an inclusive curriculum. This research is relevant in the current context, where globalization threatens the preservation of indigenous cultures [9]. By strengthening the blended learning methodology, it seeks to ensure that Waorani youth can function in modern contexts without losing their cultural roots. This study also contributes to the debate on how educational policies can adapt to cultural diversity. The Waorani community, with its own educational model, offers a practical example for other indigenous communities in Ecuador [10]. This research responds to the need for educational systems that promote autonomy and social cohesion. Its innovative approach has the potential to influence national educational policies.

The main objective of this study is to evaluate how the Ayni method Multi -Neutrosophic Methodology can strengthen the blended learning methodology in the Waorani community by integrating ancestral logic with formal educational standards to promote inclusive intercultural education. Specific objectives include analyzing the regulatory framework that supports IBE, identifying elements of Waorani ancestral logic that can be incorporated into the curriculum, and proposing strategies to overcome barriers to educational implementation. It is hypothesized that the application of the Ayni method Multi -Neutrosophic, by modeling reciprocity and resolving cultural indeterminacies, facilitates the integration of traditional and modern knowledge, improving the relevance of the

educational system. This approach makes it possible to address the tensions between Western pedagogical approaches and ancestral practices, such as oral teaching and practical observation. The research seeks to generate an educational model that respects the Waorani worldview while meeting national requirements. In addition, it aims to offer practical recommendations for teacher training and the creation of adapted educational materials. The hypothesis is based on the premise that a participatory and culturally sensitive approach can reduce educational exclusion [11]. This study also explores how reciprocity (Ayni) can be a guiding principle in curriculum design. The expected results will contribute to the literature on intercultural education in Indigenous contexts.

Intercultural education in the Waorani community requires an approach that goes beyond conventional educational models, integrating ancestral logic as a basis for teaching. Reciprocity, a central principle in the Waorani worldview, implies a balanced relationship between community, nature and knowledge [12]. This study proposes that the Ayni method Multi-Neutrosophic, by modeling this reciprocity, can overcome the limitations of traditional educational approaches. The mixed methodology combines oral and practical teaching from elders with formal academic content, ensuring meaningful learning. Lack of resources and poor teacher training have been identified as key obstacles in previous studies [8]. This work seeks to address these barriers through a participatory approach that involves the community in curriculum design. The integration of ancestral knowledge not only preserves cultural identity but also strengthens social cohesion. The Waorani community has developed its own educational practices that can serve as a model for other Indigenous communities. The research also considers the impact of public policies on the implementation of IBE. By focusing on ancestral logic, the study offers a unique perspective on intercultural education.

The blended learning methodology proposed in this study is based on the experience of the Waorani community, which has implemented an educational model that combines oral transmission with Western approaches. This model respects the Waorani worldview, including practices such as biodiversity management and the use of medicinal plants. However, implementation faces challenges such as the lack of culturally relevant educational materials [6]. The Ayni method Multi-Neutrosophic offers an innovative tool to address these limitations by modeling the interactions between educational actors (teachers, elders, students) and curricular content. The research is framed in a context where intercultural education is a recognized right, but its practical application is insufficient. The Waorani community, located in the Ecuadorian Amazon, represents an ideal case to explore innovative solutions. This study is also inspired by international experiences, such as ethno-education programs in Colombia and Venezuela [3], [5]. The integration of ancestral logic into the curriculum not only guarantees cultural preservation but also improves academic performance. The research seeks to generate a practical impact on educational policies. The mixed methodology, supported by the Ayni method Multi-Neutrosophic, can be a scalable model for other indigenous communities.

The Ecuadorian regulatory framework, including Articles 26, 27, 57, and 347 of the Constitution, establishes the right of indigenous peoples to an education adapted to their culture and language. ILO Convention 169 reinforces this principle, highlighting the importance of self-determination in educational management [2]. However, the implementation of these regulations faces practical obstacles, such as a lack of funding and teacher training. This study proposes that the Ayni method Multi-Neutrosophic methodology can facilitate the implementation of these policies by modeling community participation in curriculum design. The Waorani community, with its focus on reciprocity and connection to nature, offers a practical example of how to integrate ancestral logic into education. Research also examines how public policies can be adapted to support intercultural education. The lack of adapted educational materials is a recurring challenge in the literature [6]. This study seeks to fill this gap by proposing a curriculum that includes specific cultural content. The mixed methodology promotes educational inclusion without compromising cultural identity. The research has the potential to influence national educational policies.

Intercultural education is not only a right, but also a tool to promote equity and social justice in multicultural contexts. The Waorani community, with its rich cultural tradition, faces the challenge of preserving its identity in a globalized world [9]. This study proposes that the mixed teaching methodology, strengthened by the Ayni method Multi -Neutrosophic approach can ensure a balance between ancestral knowledge and formal education. The participation of elders and community leaders as educators is key to transmitting traditional knowledge. Research also considers the impact of intercultural education on social cohesion and community autonomy. Educational models that ignore the indigenous worldview tend to perpetuate exclusion [11]. This work seeks to reverse this trend through a participatory and culturally sensitive approach. The Waorani ancestral logic, based on reciprocity, offers a solid basis for curriculum design. The research also explores how educational policies can be adapted to the needs of indigenous communities. This study contributes to the debate on intercultural education in Latin America.

The hypothesis of this study maintains that the Ayni method Multi -Neutrosophic, by modeling reciprocity and resolving cultural indeterminacies, can improve the effectiveness of the blended learning methodology in the Waorani community. This approach allows for the integration of traditional educational practices, such as oral teaching and practical observation, with national academic standards. The research also examines how community participation can strengthen curriculum design. The lack of teacher training in interculturality is a recurring obstacle in the literature [1]. This study proposes strategies to overcome this barrier, including training programs and adapted educational materials. The Waorani community offers a unique context to explore the integration of ancestral and modern knowledge. The blended learning methodology, supported by the Ayni method Multi -Neutrosophic has the potential to transform Indigenous education in Ecuador. The research also considers the impact of public policies on the implementation of IBE [2]. This study seeks to generate practical recommendations for educational authorities. Waorani ancestral logic is a valuable resource for intercultural education.

Finally, this study contributes to the literature on intercultural education, offering an innovative model for indigenous communities. The blended learning methodology, strengthened by the Ayni method, Multi -Neutrosophic, responds to the need for an education that respects cultural diversity and promotes equity. The Waorani community, with its focus on reciprocity and connection with nature, offers a practical example of how to integrate ancestral logic into education [12]. The research also highlights the importance of community participation in curriculum design. Expected outcomes include an educational model adaptable for other indigenous communities in Ecuador. This study also seeks to influence national education policies, promoting investment in teacher training and cultural materials. Intercultural education is essential to ensure social justice in multicultural contexts [7]. This work offers a theoretical and practical basis for transforming indigenous education. The proposed methodology has the potential to be a reference in Latin America. The research concludes with recommendations to strengthen IBE in the Waorani community.

2. Preliminaries

Worldview principles with an N- alectic structure

2.1. Good Living (*Sumak*) *Kawsay*)

Good living (in Quechua, *sumak*) *kawsay* , in Aymara *sum* *The qamaña* (*qamaña*) [13], as adopted in the constitutions of the Andean countries, is a principle that proposes living in fullness and harmony with the human community and nature. More than a simple ideal of life, it constitutes a holistic paradigm that rejects the dichotomies characteristic of Western development models. In its original Andean meaning, *sumak* refers to the ideal and harmonious realization of the world, while *kawsay* means life understood as a dignified, balanced, and fulfilling existence. Other indigenous peoples share similar notions of “buen vivir” (good living) (e.g., *Teko kavi* among the Guaraní), based on collective harmony [14].

This worldview views the world as “a house where everyone lives,” emphasizing community, family, and the vitality of the territory. In n-alectic terms, Buen Vivir integrates what we might call the “truths” of different spheres: social well-being, environmental sustainability, and economic prosperity, avoiding prioritizing one to the detriment of the others. It recognizes that focusing solely on material gain, ignoring social health or the environment, is “false” progress; at the same time, neglecting basic economic needs does not lead to a full life (a “false” idealism) [15].

In complementarity: articulating an economy at the service of the community and *Pachamama* (Mother Earth) [16], simultaneously achieving social justice and ecological balance. Thus, Indigenous ethics is presented as a unified system of values that intertwines social cohesion, environmental sustainability, cultural respect, and spirituality. These are not static balances, but rather dynamic and contextual adjustments: each decision must weigh how it affects the entire fabric of life [17].

Andean cultures have traditionally prioritized decisions that integrate multiple dimensions—human, spiritual, and environmental—to maintain ecological and social harmony. This principle demands that, to be ethical, AI should not pursue a single objective (e.g., maximizing economic efficiency) at the expense of community well-being or the well-being of nature. Rather, it should optimize solutions that generate shared benefits across social, environmental, and economic spheres. [18]

In practice, guiding AI according to the *Buen Vivir principle* involves developing technologies centered on the common good: technologies that strengthen community health and education, respect ecosystem boundaries, and equitably distribute their benefits. Any AI system, no matter how powerful, must be evaluated based on its contribution to this collective and sustainable fulfillment of life.

2.2. Yanantin – Andean Complementary Duality

In the Andean worldview, *yanantin* [19] represents the union of opposing but interdependent energies, a Quechua principle often translated as the “complementarity of differences.” Long before modern physics explored the concept of dualities or multivalued logics emerged in philosophy, Andean peoples already conceived of reality as composed of mutually necessary pairs: feminine and masculine, light and dark, sun and moon, mountain and valley. These opposites are neither irreconcilable nor hierarchically ordered; rather, they coexist harmoniously to form a unified whole.

Thus, the dynamic relationship of balanced polarities is considered the fundamental organizing principle of creation; existence itself depends on the harmonious exchange between opposing forces, which must interact without destroying each other. [20] Logically, each element of the pair can be understood as a partial “truth”: each contains valuable and genuine aspects in its own right, but also proves “false” or incomplete if it attempts to encompass the whole without its counterpart. A greater truth emerges from the interaction of both sides. Andean reasoning, therefore, resists the notion that one must choose only one side of duality; instead, it seeks a third space of balance in which both halves coexist.

Neutrosophic logic [21] offers a formal model for this perspective, allowing for intermediate values that represent collaboration rather than exclusion between opposites. A “fourfold neutrosophic logic” has been proposed to mathematically represent Andean duality: truth (T) and falsity (F) are refined by introducing two types of indeterminacy: one leaning toward truth (I_T , symbolizing the complementary relationship where opposites support each other), and one leaning toward falsity (I_F , symbolizing the contradictory tension when opposites clash) [10]. This formalization reflects the complexity of real life in which opposites can be simultaneously complementary and contradictory. For example, woman is traditionally said to complement man, but sometimes she is also “his contradiction” in everyday coexistence: from the friction between the two comes mutual adjustment and growth.

Applied to artificial intelligence, the *yanantin principle* suggests that the design and implementation of technology must value multiple, opposing but complementary perspectives. A truly ethical and effective

AI could emerge from the integration of Western scientific knowledge with traditional indigenous wisdom, rather than privileging one and discarding the other [22]. This also entails balancing automation with human intervention: neither delegating all critical decisions to algorithms devoid of human judgment (blind technocracy), nor rejecting technological innovation altogether (sterile Luddism), but rather achieving complementary interaction.

This principle reminds us that, when faced with ethical dilemmas, the optimal solution often lies not in choosing one extreme, but in finding synergy between the two [23]. Applied to AI decision-making, *yanantin* would encourage the development of hybrid systems in which AI enhances human capabilities while humans supervise and correct the AI, creating balanced teams of humans and machines. Similarly, in regulating AI, we must reconcile the freedom of innovation (valued as truth by the economic sector) with social and cultural protection (valued as truth by communities and public ethics), seeking a fertile middle ground. In short, *Yanantin* invites us to conceive of AI not as a soloist, but as a duo, harmonizing different forces to achieve a result more complete and balanced than the sum of its parts.

2.3. Ch'ixi thought: complementary contradiction and the intermediate state

The concept of *ch'ixi* arises from the Andean- Aymara worldview. , popularized by Bolivian sociologist Silvia Rivera Cusicanqui [24]. *Ch'ixi* Originally refers to a mottled or speckled color, a mixture of black and white in which the two do not blend but coexist without canceling each other out (Figure 1). In cultural terms, Rivera employs the concept to describe a mestizo epistemology where Indigenous and Western elements intertwine without fully synthesizing into a homogeneous whole. It is, therefore, a way of being multiple at once: embracing internal contradiction as integral to identity. A *ch'ixi* world is one in which different truths and logics coexist in unresolved tension, a "fabric made of conflict and complementarity" [25].

This intermediate space (*taypi* in Aymara) [26] is "full of tensions", but also of creative vitality, as new possibilities arise from continuous friction without any perspective establishing hegemony. In Andean textile metaphors, the *taypi El ch'ixi* represents the center of the fabric, balancing symmetries and rhythms, allowing threads of opposite colors to form a complex pattern (Figure 1). As an n- alethic structure , the *ch'ixi* It embodies the idea that something can be true or false depending on the context, or that two contradictory statements can be held simultaneously without canceling each other out. For example, a person can feel fully indigenous and, at the same time, modern, without needing to choose a singular identity: both "truths" coexist within the individual, even though they may appear mutually exclusive from the perspective of classical logic [27].

paraconsistent logics [28], in which a proposition can be partially true and partially false at the same time. *Ch'ixi* thought It invites us to "voluntarily inhabit discomfort and questioning," accepting ambiguity rather than rushing to resolve it. This discomfort is fertile: it allows opposing perspectives to coexist and dialogue.

In AI ethics, a *ch'ixi approach* It is valuable for addressing the uncertainties and incompatibilities that arise in the interaction between modern technologies and traditional cultures. For example, when introducing an AI system for medical diagnosis in an Indigenous community, tensions may arise between the Western biomedical worldview (based on data and molecular biology) and the community's traditional medicine (based on spirituality and herbal knowledge). A conventional approach might consider them mutually exclusive: one should be imposed as "true" and the other dismissed as "false superstition." In contrast, a *ch'ixi approach* This perspective would seek coexistence [29]: AI could be used for rapid disease detection, while traditional treatments are respected and practiced simultaneously for other conditions or for the patient's spiritual balance. Both visions are not necessarily merged, but are allowed to interact in a creative tension, combining the strengths of each.

This contradictory pluralism recognizes that not everything can be seamlessly integrated—ideological frictions will persist—but collaboration toward shared goals (such as community health) remains possible. Similarly, in the data field, a *ch'ixi approach* would accept that the Western notion of individual data ownership and the Indigenous view of knowledge as sacred and communal may conflict [30]. Instead of imposing a single data policy, a dual system could be designed: some data are governed by traditional community protocols (e.g., prior consultation, collective consent), while other data are managed through modern frameworks; both structures coexist within the digital ecosystem.

This "informational mixing" may seem inconsistent to purists on both sides, but *the ch'ixi It* teaches that from apparent incoherence a more inclusive and resilient practice can emerge, better adapted to the complexity of the real world. In short, *ch'ixi It* contributes to ethical AI by promoting comfort with contradiction: the ability to design systems in which different logics coexist and solutions are not uniform, but fragmented, flexible, and context-specific, reflecting diversity without eliminating it.

2.4. In Lak'ech – Relationality and universal reciprocity

In Lak'ech It is both an expression of Mayan wisdom and a deeply relational ethical principle. Commonly translated as "I am another you; you are another me," it encapsulates the notion that individual existence is meaningless in isolation from others. While the authenticity of this exact phrase has been debated—and, according to specialists, it is not commonly used in everyday conversation among Mayan speakers and may represent a very literal translation—the phrase still accurately conveys the essential Mayan philosophical idea of interconnectedness and collectivity. As the Yucatecan tradition explains: "I do not exist without you, and you do not exist without me. Therefore, you and I exist through our relationship; we exist through the we." [31]

The Mayan worldview[32] conceives of the universe as a vast web of interdependence: individuals, communities, animals, plants, winds, spirits, and ancestors are all interconnected, and nothing exists apart from their relationships. Every being exists because it participates in a greater whole, *Us*, which also includes nature. From this arises an ethic of reciprocity: "If I respect you, I respect myself; if I harm you, I harm myself." This is not merely a poetic metaphor, but a literal understanding of reality: harm inflicted on another being, human or non-human, inevitably reflects back, since individual identity is constituted by relational bonds.

In this context, the Mayan concept of zero (*nik'*), a mathematical and cosmological innovation, reinforces the non-dual and cyclical character of this worldview (Figure 3). Far from representing a mere absence, the Mayan zero signifies a moment of transition, a state of potentiality from which life and time emerge and return. This idea resonates with neutrosophic logic, especially in its n-alethic formulation, which allows for the coexistence of truth (T), falsity (F), and indeterminacy (I) within any proposition. Just as zero is not an absolute void but a threshold within a cycle, *In Lak'ech It* reflects a relational ethic where meaning emerges from dynamic interconnectedness rather than isolated certainty. Both Mayan and neutrosophic systems reject rigid binarities and embrace multiplicity, change, and contextual knowledge as fundamental. As Batz [33] explains, the Mayan zero is a vital symbol of interdependence, echoing the ontological commitments of relational philosophies such as neutrosophy.

Allectic Neutrosophic Framework, *In Lak'ech It* can be understood as a transcendence of the self-other duality through a third mediating term: the *we*. Rather than considering self and other as mutually exclusive, this Mayan principle affirms both relational unity and individual distinction: "you are another self" does not imply fusion, but coexistence. This philosophical tension finds resolution in community, which functions as an inclusive middle ground. A powerful symbol of this duality in unity is the Mayan concept of zero. [34] Far from denoting absolute nothingness, the Mayan zero signifies a fertile void, a moment of pause, transition, and interconnected potentiality. This symbolic neutrality evokes the

indeterminate component (I) in neutrosophic logic, where meaning and value exist in fluctuating degrees of truth, falsity, and indeterminacy, shaped by relational and contextual dynamics.

Applied to the ethics of AI, *In Lak'ech* demands a reorientation from extractive and anthropocentric approaches toward a relational ethic based on reciprocity and interconnectedness. Decisions must consider all members of the web of life—humans, nonhumans, and the environment—as part of a unified network. This principle demands inclusive practices in data governance, especially with regard to Indigenous sovereignty and participatory design. Echoing the regenerative symbolism of the Mayan zero, AI systems must be conceived not as tools of domination, but as technologies of care: restorative acts that reflect our interconnected identity. In this sense, *In Lak'ech* becomes a guiding ethic for the development of an AI that nurtures rather than exploits, incorporating into each algorithm a recognition of the Other as an integral part of Being.

2.5. *Nepantla* as a N- Alethic threshold: creative ambiguity and sustained transition

The concept of *nepantla*, of Nahuatl origin, refers to being “between” or in “no man’s land,” a liminal space between two worlds, cultures, or states of being. Beyond its linguistic connotation, thinkers such as Gloria Anzaldúa [35] have claimed *nepantla* as an existential and political category that allows us to simultaneously inhabit the old and the new, the imposed and the original, without erasing the tensions that arise between them. *Nepantla* thus becomes a state of fertile ambiguity, where certainties are fractured, but where new identities, expanded worldviews, or more integrative value systems can also emerge.

From the perspective of n- alethic reasoning, *nepantla* It is neither a state of paralysis nor an irresolvable contradiction, but a complex configuration in which elements of truth (T), falsity (F), and indeterminacy (I) coexist. This logic, developed within the framework of Florentin Smarandache, Neutrosophy, breaks with classical binary logics by allowing ideas, beliefs, or systems to be evaluated not only as true or false, but also as partially true, contradictory, or uncertain to varying degrees. In this sense, *nepantla* It represents a genuinely neutrosophic space, where knowledge coexists in tension and where the boundaries between opposites blur, giving rise to hybrid possibilities[36].

Applied to the field of sustainability, *Nepantla* It can be interpreted as the threshold of transition between an unsustainable paradigm and an emerging one. In this transition zone, decisions and actions are imbued with uncertainty: old structures persist, while new ones are not yet consolidated [37]. From a conventional logical perspective, this period might appear chaotic or unproductive; however, from a n- alethic perspective, this intermediate state is necessary and revealing. It allows us to recognize that there is no single path to a sustainable future, but rather multiple trajectories that must dialogue, complement or even contradict each other to drive an authentic transformation.

The *nepantla* , as experienced by many Indigenous communities, especially under the pressures of colonization and globalization, represents a cultural and epistemic space where ancestral knowledge and modern technologies like AI intersect. This “ *technological nepantla* ” embodies creative tension rather than contradiction, making it fertile ground for applied neutrosophy . Within an n- alethic framework, the *nepantla* becomes a dynamic threshold—a space of ambiguity and coexistence—through which new, inclusive and sustainable forms of knowledge and governance can emerge.

2.6 Multineutrosophic sets and N- alethic logic to represent epistemic plurality

To formally model the complex, fluid, and often contradictory structures that characterize indigenous epistemologies—such as *Nepantla* , *In Lak'ech* , *Ch'ixi* , *Yanantin* and *Buen Vivir*— we turn to the framework of Neutrosophic Logic. This advanced logic allows for the simultaneous representation of truth, falsity, and indeterminacy, offering a formal structure for n- alethical reasoning. The fundamental

elements of Neutrosophic Sets, together with their refined, multivalued extensions, provide the mathematical tools necessary to express these ancient concepts not as symbolic metaphors, but as rigorous components of ethical, sustainable, and intercultural systems design [38].

The following definitions describe the basic constructs of neutrosophic sets:

Definition 1 [39]: The neutrosophic set N is defined by three membership functions: the truth membership function T_A , the indeterminacy membership function I_A , and the falsity membership function F_A , where U represents the Universe of Discourse. and $\forall x \in U, T_A(x), I_A(x), F_A(x) \subseteq]^{-}0, 1^{+}[$, and $^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}$.

By definition, $T_A(x), I_A(x)$, and $F_A(x)$ are standard or nonstandard real subsets of $]^{-}0, 1^{+}[$ and, hence, $T_A(x), I_A(x)$ and $F_A(x)$ can be subintervals of $[0, 1]$. $^{-}0$ and 1^{+} belong to the set of hyperreal numbers.

Definition 2 [40]: The Single Valued Neutrosophic Set (SVNS) A over U is $A = \{ \langle x, T_A(x), I_A(x), F_A(x) \rangle : x \in U \}$, where $T_A: U \rightarrow [0, 1]$, $I_A: U \rightarrow [0, 1]$ and $F_A: U \rightarrow [0, 1]$. $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. The Single Valued Neutrosophic Number (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

worldviews like *Nepantla*, *In Lak'ech*, *ch'ixi*, *Yanantin* and *Good Living* (*Sumak Kawsay*) embody ways of thinking that challenge traditional binary logics by operating within an n -alethic structure, one in which truth, falsity, and indeterminacy coexist. This logic can be formalized through the Refined Neutrosophic Ensemble (RNS), which decomposes the classical components of neutrosophic logic into sublevels of truth (i), indeterminacy (I_i) and falsity (F_i), together with their isomorphic model, the MultiNeutrosophic Set (MNS). These structures allow to accurately represent complex, ambiguous or transitional contexts, precisely the types of realities described by these ancient principles [10].

Therefore, both Refined Neutrosophic Sets [41] and Multi-Neutrosophic Sets [42] not only enable the representation of these n -alethical structures, but also support their application in fields such as AI ethics, sustainability, and intercultural decision-making. This articulation between advanced mathematical logic and ancestral wisdom not only validates indigenous epistemologies in formal terms, but also enriches the understanding and design of more just, inclusive, and life-harmonious technological systems.

Definition 3 [42]. The Subset-Refined Neutrosophic Set (SRNS). Let $\mathcal{U}$ be a universe of discourse and θ be a set $R \subset \mathcal{U}$. Then, a Subset-Refined Neutrosophic R is defined as follows: $R = \{x, x(T, I, F), x \in U\}$, where T is refined/split into p subtruths, $T = \langle T_1, T_2, \dots, T_p \rangle, T_j \subseteq [0, 1], 1 \leq j \leq p$; I is refined/split into r subindeterminacies, $I = \langle I_1, I_2, \dots, I_r \rangle, I_k \subseteq [0, 1], 1 \leq k \leq r$, and F is refined/split into s subfalsehoods, $F = \langle F_1, F_2, \dots, F_s \rangle, F_l \subseteq [0, 1], 1 \leq l \leq s$, where $p, r, s \geq 0$ are integers, and $p + r + s = n \geq 2$, and at least one of p, r, s is ≥ 2 to ensure the existence of refinement (splitting).

Definition 4 [42]. The MultiNeutrosophic Set (or MultiNeutrosophic Set Subset SMNS). Let $\mathcal{U}$ be a universe of discourse and M a subset of it. Then, a $M = \{x, x(T_1, T_2, \dots, T_p; I_1, I_2, \dots, I_r; F_1, F_2, \dots, F_s)\}, x \in U$, MultiNeutrosophic Set is: where p, r, s are integers $\geq 0, p + r + s = n \geq 2$ and at least one of p, r, s is ≥ 2 , to ensure the existence of a multiplicity of at least one neutrosophic component: truth/belonging, indeterminacy or falsity/non-belonging; all

subsets $T_1, T_2, \dots, T_p; I_1, I_2, \dots, I_r; F_1, F_2, \dots, F_s \subseteq [0, 1]; 0 \leq \sum_{j=1}^p \inf T_j + \sum_{k=1}^r \inf I_k + \sum_{l=1}^s \inf F_l \leq \sum_{j=1}^p \sup T_j + \sum_{k=1}^r \sup I_k + \sum_{l=1}^s \sup F_l \leq n$.

This expression sets general limits for refined or multivalued neutrosophic components. It states that the sum of the minimum (infimum) values of all truth, uncertainty, and falsity components must be greater than or equal to zero, while the sum of their maximum (supreme) values must not exceed a total

- Johanna Estefanía Calle Imbaquingo, Karen Milagros Díaz Salambay, Jordy Alexis Vargas Yumbo, Kevin Christopher Carrasco Azogue. Intercultural Education from Ancestral Logic: Application of the Ayni Method Multi -Neutrosophic to Strengthen Mixed Methodology in the Waorani Community.*

- iii. And if $S(T_a, I_a, F_a) = S(T'_a, I'_a, F'_a)$ then $SVMNT = SVMNT'$, then go to the second step. Calculate the precision function (difference between truth and falsehood) (8).

$$\begin{aligned} A(T_a, I_a, F_a) &= T_a - F_a \\ A(T'_a, I'_a, F'_a) &= T'_a - F'_a \end{aligned} \quad (2)$$

- i. If $A(T_a, I_a, F_a) \geq A(T'_a, I'_a, F'_a)$ then $SVMNT \geq SVMNT'$,
 ii. If $A(T_a, I_a, F_a) \leq A(T'_a, I'_a, F'_a)$ then $SVMNT \leq SVMNT'$,
 iii. And if $A(T_a, I_a, F_a) = A(T'_a, I'_a, F'_a)$ then $SVMNT = SVMNT'$, then go to the third step. Calculate the certainty (truth) function (9).

$$\begin{aligned} C(T_a, I_a, F_a) &= T_a \\ C(T'_a, I'_a, F'_a) &= T'_a \end{aligned} \quad (3)$$

- i. If $C(T_a, I_a, F_a) \geq C(T'_a, I'_a, F'_a)$ then $SVMNT \geq SVMNT'$,
 ii. If $C(T_a, I_a, F_a) \leq C(T'_a, I'_a, F'_a)$ then $SVMNT \leq SVMNT'$,
 iii. And if $C(T_a, I_a, F_a) = C(T'_a, I'_a, F'_a)$ then $SVMNT = SVMNT'$ they are multi-neutrosophically equal, that is $T_a = T'_a, I_a = I'_a, F_a = F'_a$, or their corresponding averages of truth, indeterminacy and falsity are equal.

When some sources contribute with different levels of importance, weighted **Averages**, denoted as and for the respective multineutrosophic tuples, $T'_{wa}, I'_{ua}, F'_{va}$, are used T_{wa}, I_{ua}, F_{va} . Since the sources can be fully independent, partially independent, or dependent, the sum of the weights is not limited to one. Therefore, the weights $w_1, w_2, \dots, w_p, u_1, u_2, \dots, u_p, v_1, v_2, \dots, v_p$ They are defined within the interval $[0,1]$, and their sums can be less than, equal to, or greater than 1. The Score, Precision, and Certainty functions are applied to these weighted averages to establish a more nuanced classification of multineutrosophic items.

3. Material and methods

This study employs Multineutrosophic Sets (MNS) as a formal mechanism for representing the coexistence of diverse ethical judgments in culturally heterogeneous environments. In neutrosophic logic, any proposition, such as “This AI system improves community health,” is evaluated based on its truth value (T), indeterminacy (I), and falsity (F), each with independent values from 0 to 1. The refined version allows for multiple sources or degrees of each component: $T = \{T_1, T_2, \dots, T_p\}$, $I = \{I_1, I_2, \dots, I_r\}$, and $F = \{F_1, F_2, \dots, F_s\}$, reflecting plural and possibly conflicting points of view.

This structure is ideal for n-aletic reasoning, which embraces the coexistence of truths, falsehoods, and uncertainties without imposing a binary resolution. Particularly in the ethics of AI applied to healthcare, the interaction between ancestral knowledge systems and algorithmic models generates zones of ambiguity (*nepanitla*) and contradiction (*ch'ixi*), which require ethical reasoning adapted to tension, dialogue and negotiated consensus.

This article presents an approach called the Multineutrosophic Ayni Method, inspired by the Andean principle of *Ayni* —a form of reciprocal and ethical coexistence that values balance, mutual respect, and dynamic harmony. This method models the ethical interaction between diverse sources of judgment without forcing unification [12]. Rather than erasing differences, it honors them through a formal structure that allows for negotiated convergence. The name reflects both the mathematical foundation of neutrosophic logic and the cross-cultural epistemology it seeks to respect and operationalize.

Neutrosophic Consensus Measure [44] based on Euclidean distance, designed to quantify the degree of alignment (or divergence) between diverse assessments provided by multiple sources. Rather than imposing consensus, this measure preserves the integrity of plural perspectives, while offering a metric for identifying zones of convergence in intercultural ethical deliberation. This approach improves decision-making processes by highlighting epistemic diversity as a strength rather than a limitation.

Definition 5: Euclidean multineutrosophic consensus measure

Sea

$$x(T_1, T_2, \dots, T_p; I_1, I_2, \dots, I_r; F_1, F_2, \dots, F_s) \quad (4)$$

be a Multi-Neutrosophic evaluation of an element $x \in U$, where each component reflects values from distinct sources.

Leave:

$$\bar{T} = \frac{1}{p} \sum_{j=1}^p T_j \quad (5)$$

$$\bar{I} = \frac{1}{r} \sum_{k=1}^r I_k \quad (6)$$

$$\bar{F} = \frac{1}{s} \sum_{l=1}^s F_l \quad (7)$$

So, the Neutrosophic Consensus Measure C_x is defined as:

$$C_x = 1 - \frac{1}{3} \left(\sqrt{\frac{1}{p} \sum_{j=1}^p (T_j - \bar{T})^2} + \sqrt{\sum_{k=1}^r \frac{1}{r} (I_k - \bar{I})^2} + \sqrt{\frac{1}{s} \sum_{l=1}^s (F_l - \bar{F})^2} \right) \quad (8)$$

where p , r , and s represent the number of truth, indeterminacy, and falsity values, respectively, and $n = p + r + s$ is the total number of neutrosophic values.

The result $C_x \in [0, 1]$, where:

$C_x = 1$ indicates maximum consensus (no dispersion),

$C_x \approx 1$ Indicates minimum consensus (maximum dispersion).

This measure reflects the degree of alignment between various sources, without requiring exact agreement, making it especially suitable for ethical assessments in intercultural and pluralistic settings.

To operationalize plural ethical assessment in culturally diverse contexts, this study proposes the Ayni Multineutrosophic Method, a step-by-step approach that integrates ancestral relational ethics (Ayni) with neutrosophic logic to assess the acceptability of sociotechnical systems. The method is developed as follows:

Step 1: Identify multiple stakeholders

Identify a diverse set of stakeholders involved in or affected by the proposed intervention. These may include technical experts, community elders, traditional knowledge holders, public officials, and other relevant stakeholders. Define a consensus threshold (θ), where $\theta \in [0, 1]$, as a predefined, context-dependent value.

Step 2: Neutrosophic elicitation

Each stakeholder evaluates a given ethical proposition (e.g., “This AI system is beneficial and ethically appropriate”) in terms of:

- Truth (T) – perceived ethical and practical validity.
- Indeterminacy (I) – uncertainty or unresolved concerns.
- Falsehood (F) – perception of harm or ethical inadequacy.

Each component can be expressed as a set of degrees $T = \{T_1, \dots, T_p\}$, $I = \{I_1, \dots, I_r\}$, $F = \{F_1, \dots, F_s\}$, forming a multineutrosophic tuple.

Step 3: Calculate added values

Calculate the average of each component:

$$\bar{T} = \frac{1}{p} \sum_{j=1}^p T_j, \quad \bar{I} = \frac{1}{r} \sum_{k=1}^r I_k, \quad \bar{F} = \frac{1}{s} \sum_{l=1}^s F_l \quad (9)$$

Step 4: Calculate the neutrosophic score and accuracy

Use the scoring function:

$$S = \frac{1}{3} (\bar{T} + (1 - \bar{I}) + (1 - \bar{F})) \quad (10)$$

and the precision function:

$$A = \bar{T} - \bar{F} \quad (11)$$

These values provide a quantitative reflection of collective ethical alignment and divergence.

Step 5: Calculate the Euclidean multineutrosophic consensus measure

To assess the level of convergence among stakeholders, calculate C_x (8).

Consensus threshold rule: if yes $C_x < \theta$, a new round of deliberation is initiated to address dissent and refine the proposal.

Step 6: Ayni-based adjustment

If the consensus threshold is not reached, a culturally rooted *Ayni process* is activated:

- Stakeholders openly express their concerns and expectations.
- Proposals are ethically renegotiated through community logic, rituals, or symbolic mediation.
- Adjustments are made to the technological design or implementation strategy.

Step 7: Re-evaluation and iteration

A second (or subsequent) neutrosophic assessment is conducted with updated values. If the consensus threshold is met, the proposal advances with intercultural legitimacy. Otherwise, further dialogue and reformulation may be required.

This method recognizes plural truths, dynamic uncertainties, and situated falsehoods, without forcing premature resolution. It promotes ethical alignment not through top-down authority, but through dialogic convergence based on both formal logic and ancestral reciprocity. As such, the Ayni Multi-Neutrosophic Method constitutes a replicable, flexible, and culturally sensitive approach to ethical decision-making in AI-based healthcare systems and beyond.

4. Case study

Problem Context.

The Ecuadorian Ministry of Education, in collaboration with indigenous organizations, proposes the implementation of a new "**Mixed Intercultural Curriculum**" for basic education in the Waorani territory. The objective of this curriculum is to integrate the community's ancestral knowledge (ethnobotany, cosmogony, jungle survival techniques, oral history) with the national curriculum standards (mathematics, natural sciences, language and literature).

The proposal, although well-intentioned, sparks a profound debate. While some see an opportunity to revitalize culture, others fear it is a way of "folklorizing" ancestral knowledge and subordinating it to Western logic. To mediate this epistemic conflict, the **Ayni Method** was applied. **Multi Neutrosophic** to evaluate the proposal collaboratively.

Participants (Stakeholders)

An evaluation board is formed with the following key actors:

1. **Woorani Wise Elder (Pikenani)**: Guardian of oral tradition and spiritual knowledge. His priority is the intact transmission of the Woorani worldview.
2. **Woorani Organization**: Political representative of the community. Seeks a balance that strengthens autonomy while facilitating young people's access to higher education and the labor market.
3. **Community School Teacher**: Understands the daily pedagogical challenges and the need for adequate resources and training to implement a curriculum of this nature.
4. **Ministry of Education expert**: Assesses standardization, academic quality, and compliance with national learning objectives.
5. **Woorani Youth Representative**: High school graduate. He desires an education that connects him with his roots, but also provides him with the tools to navigate outside his territory.

Proposal to Evaluate

The following proposition is evaluated by the council:

Woorani ancestral knowledge with national educational standards, strengthening cultural identity without compromising academic quality."

Application of the Ayni Method Multi -Neutrosophic

Step 1: Identify Stakeholders and Consensus Threshold

Stakeholders have already been identified. The council sets a **consensus threshold (θ) of 0.85**. This high value is chosen due to the project's critical importance to the community's cultural and educational future. If the consensus measure C_x is less than 0.85, a process of dialogue and adjustment will be required.

Step 2: Neutrosophic Elicitation (First Assessment)

Each council member evaluates the proposition. Their judgments are grouped into components of Truth (T), Indeterminacy (I), and Falsehood (F).

- **Sources of Truth (T)**: Reflect the degree of agreement and perception of benefits.
 - $p = 3$ evaluators (Ministry Expert, Woorani Leader, Woorani Youth).
 - Assigned values: $T = \{0.95, 0.60, 0.75\}$. The expert fully trusts the academic structure (0.95), the leader is optimistic but cautious (0.60), and the young person sees high potential (0.75).
- **Sources of Indeterminacy (I)**: They represent doubt, uncertainty about implementation and results.
 - $r = 2$ evaluators (Woorani Leader , Community Teacher).

- Assigned values: $I = \{0.70, 0.85\}$. The leader is unsure of how practical conflicts will be resolved (0.70), and the teacher has serious doubts about the lack of training and materials (0.85).
- **Sources of Falsehood (F):** Indicate the degree of disagreement and the perception of risks or damages.
 - $s = 2$ evaluators (Wise Elder, Community Teacher).
 - Assigned values: $F = \{0.90, 0.40\}$. The Elder perceives a very high risk of cultural erosion (0.90), while the teacher sees a moderate risk of pedagogical failure (0.40).

The tuple initial multi -neutrosophic for the curricular project is:

For Word: Insert > Equation

Initial resume = $\{\{0.95, 0.60, 0.75\}, \{0.70, 0.85\}, \{0.90, 0.40\}\}$

Steps 3, 4 and 5: First Assessment Calculations

Step 3: Calculate Added Values

We calculate the average of each component with high precision.

- **Average Truth (T^-):**

$$\bar{T} = \frac{0.95 + 0.60 + 0.75}{3} = \frac{2.30}{3} = 0.766667$$

- **Average Indeterminacy ($\bar{I}$):**

$$\bar{I} = \frac{0.70 + 0.85}{2} = \frac{1.55}{2} = 0.775000$$

- **Average Falsehood (F^-):**

$$\bar{F} = \frac{0.90 + 0.40}{2} = \frac{1.30}{2} = 0.650000$$

Step 4: Calculate Score and Accuracy

- **Scoring Function (S):**

$$S = \frac{2 + \bar{T} - \bar{I} - \bar{F}}{3} = \frac{2 + 0.766667 - 0.775000 - 0.650000}{3} = \frac{1.341667}{3} = 0.447222$$

- **Precision Function (A):**

$$A = T - F = 0.766667 - 0.650000 = 0.116667$$

Intermediate Interpretation: The score ($S \approx 0.45$) is low, indicating a mediocre overall assessment.

The precision ($A \approx 0.12$) is positive but very close to zero, reflecting a slight bias toward benefits, but strongly outweighed by perceived risks.

Step 5: Calculate the Consensus Measure (C_x)

Multi -Neutrosophic Consensus Measure formula:

$$C_x = 1 - \sqrt{\left[\left(\frac{1}{p+r+s}\right) \times \left(\sum (T_i - \bar{T})^2 + \sum (I_j - \bar{I})^2 + \sum (F_k - \bar{F})^2\right)\right]}$$

- **Sum of squares for T:**

$$(0.95 - 0.766667)^2 = (0.183333)^2 = 0.033611$$

$$(0.60 - 0.766667)^2 = (-0.166667)^2 = 0.027778$$

$$(0.75 - 0.766667)^2 = (-0.016667)^2 = 0.000278$$

$$\Sigma(T_i - T)^2 = 0.033611 + 0.027778 + 0.000278 = 0.061667$$

- **Sum of squares for I:**

$$(0.70 - 0.775000)^2 = (-0.075)^2 = 0.005625$$

$$(0.85 - 0.775000)^2 = (0.075)^2 = 0.005625$$

$$\Sigma(I_j - \bar{I})^2 = 0.005625 + 0.005625 = 0.011250$$

- **Sum of squares for F:**

$$(0.90 - 0.650000)^2 = (0.25)^2 = 0.062500$$

$$(0.40 - 0.650000)^2 = (-0.25)^2 = 0.062500$$

$$\Sigma(F_k - F)^2 = 0.062500 + 0.062500 = 0.125000$$

- **Total number of values (n):**

$$n = p + r + s = 3 + 2 + 2 = 7$$

- **Final calculation of C_x :**

$$C_x = 1 - \sqrt{\left[\left(\frac{1}{7}\right) \times (0.061667 + 0.011250 + 0.125000)\right]}$$

$$C_x = 1 - \sqrt{\left[\left(\frac{1}{7}\right) \times (0.197917)\right]}$$

$$C_x = 1 - \sqrt{[0.02827386]}$$

$$C_x = 1 - 0.16814833$$

$$C_x \approx 0.831852$$

Result: The consensus measure is $C_x \approx 0.8319$.

Comparison with the threshold: $0.8319 < 0.85$. **Consensus has not been reached.**

Ayni -Based Adjustment

Since the threshold was not reached, a reciprocal dialogue process (*Ayni*) is activated.

- The **Wise Old Man** expresses that the curriculum should be structured around the cycles of nature, not academic semesters. He proposes that "living books" (the jungle, rivers) be the primary sources of teaching.

- The **teacher** requires a two-year training program, co -designed with the elders, and the creation of relevant bilingual teaching materials.
- The **Waorani leader** is negotiating with the **Ministry's expert** to make the curriculum more flexible, allowing 40% of teaching time to be managed autonomously by the community, under the guidance of the elders.
- The **young man** suggests creating a digital platform to document the stories of the elderly, creating a living cultural archive.

These adjustments substantially modify the original proposal, making it more participatory and respectful of ancestral logic.

Step 6: Re-evaluation and Iteration (Second Evaluation)

The council re-evaluates the *amended proposal*.

- **New Truth Values (T):** $T = \{0.85, 0.80, 0.90\}$ The Ministry expert slightly lowers his optimism (0.85) due to the loss of standardization, but the leader (0.80) and the young man (0.90) increase their support.
- **New Values of Indeterminacy (I):** $I = \{0.30, 0.20\}$ The doubts of the leader (0.30) and the teacher (0.20) decrease drastically thanks to the concrete commitments of training and flexibility.
- **New Falsehood Values (F):** $F = \{0.25, 0.15\}$ The Elder's fear is significantly reduced (0.25) when seeing that ancestral logic will be central, and the teacher now sees a much lower risk of failure (0.15).

The new tuple is:

Adjusted curriculum = $\{\{0.85, 0.80, 0.90\}, \{0.30, 0.20\}, \{0.25, 0.15\}\}$

Recalculation of the Second Evaluation

- **New Averages:**

$$\bar{T} = \frac{0.85 + 0.80 + 0.90}{3} = \frac{2.55}{3} = 0.850000$$

$$\bar{I} = \frac{0.30 + 0.20}{2} = \frac{0.50}{2} = 0.250000$$

$$\bar{F} = \frac{0.25 + 0.15}{2} = \frac{0.40}{2} = 0.200000$$

- **New Scoring and Accuracy:**

$$S = \frac{2 + 0.85 - 0.25 - 0.20}{3} = \frac{2.40}{3} = 0.800000$$

$$A = 0.85 - 0.20 = 0.650000$$

• **New Consensus Calculation (C_x):**

$$\begin{aligned}\Sigma(T_i - T)^2 &= (0.85 - 0.85)^2 + (0.80 - 0.85)^2 + (0.90 - 0.85)^2 = 0 + 0.0025 + 0.0025 \\ &= 0.005000\end{aligned}$$

$$\Sigma(I_j - \bar{I})^2 = (0.30 - 0.25)^2 + (0.20 - 0.25)^2 = 0.0025 + 0.0025 = 0.005000$$

$$\Sigma(F_k - F)^2 = (0.25 - 0.20)^2 + (0.15 - 0.20)^2 = 0.0025 + 0.0025 = 0.005000$$

$$C_x = 1 - \sqrt{\left[\left(\frac{1}{7}\right) \times (0.005000 + 0.005000 + 0.005000)\right]}$$

$$C_x = 1 - \sqrt{\left[\frac{0.015000}{7}\right]}$$

$$C_x = 1 - \sqrt{[0.00214286]}$$

$$C_x = 1 - 0.04629100$$

$$C_x \approx 0.953709$$

Final Result: The new consensus measure is $C_x \approx 0.9537$

Final Comparison: $0.9537 > 0.85$. **The consensus threshold has been crossed!** The revised proposal is moving forward with a high degree of intercultural legitimacy and community support.

Comparative analysis of the Waorani Mixed Curriculum evaluation before and after the Ayni reciprocal dialogue process

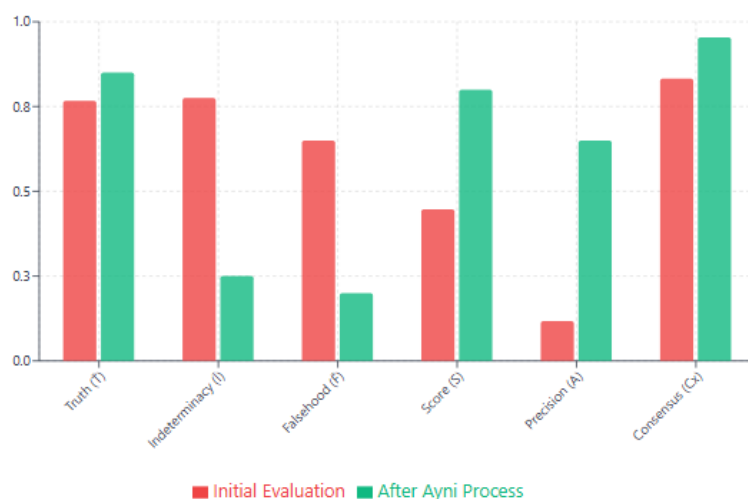


Figure 1: Evolution of Multi-Neutrosophic Components

5. Discussion

Ayni Method Multi -Neutrosophic transcends a simple multi-criteria decision-making tool to become an **epistemic mediation procedure**. The first evaluation, with its low consensus ($C_x \approx 0.83$), did not represent a failure, but an accurate diagnosis of the tensions between the standardized vision of the State and the Waorani worldview. The initial score ($S \approx 0.45$) quantitatively reflected the widespread skepticism.

The true value of the method lay in **Step 6 (Ayni Adjustment)**. By making dissent explicit, the method forced the parties into a dialogue based on reciprocity. It was not about one side “winning,” but about finding a *Yanantin equilibrium point*, where formal education and ancestry complement each other rather than cancel each other out. The final, co -designed proposal generated a dramatic increase in the score ($S=0.80$) and, crucially, surpassed the consensus threshold ($C_x \approx 0.95$).

This approach directly addresses the challenges mentioned in the research summary: a lack of teacher training and resources. *Ayni ’s process* transformed these needs from barriers to negotiated and accepted conditions for the project's viability. The method, therefore, not only evaluates a static proposal but catalyzes its transformation into a culturally relevant and sustainable solution.

6. Conclusions

This study demonstrates that the **Ayni Method Multi -Neutrosophic** is a robust and culturally sensitive tool for strengthening blended learning methodologies in Indigenous contexts such as the Waorani community. Key findings include:

1. **Formalizes Intercultural Dialogue:** The method translates qualitative perceptions, doubts and fears into a mathematical structure (the tuple multi -neutrosophic) that allows to visualize and quantify the degree of alignment between different worldviews.
2. **Promotes Reciprocity (Ayni):** By integrating a consensus threshold and a feedback loop, the method does not seek to average opinions to impose a solution, but rather facilitates a process of negotiation and mutual adjustment that respects epistemic plurality.
3. **Generates Legitimacy and Ownership:** The end result is not just a mathematically "optimal" decision, but a co -constructed proposal that enjoys the support and legitimacy of the community, increasing the likelihood of successful and sustainable implementation.
4. **Replicable Model:** The conceptual and methodological framework presented here offers an adaptable model to address similar dilemmas in other indigenous communities, serving as a bridge between ancestral knowledge and public policies in education, health, and territorial governance.

Multi -neutrosophic logic with the ancestral principle of Ayni offers a path to building a truly intercultural education that fosters social cohesion and the autonomy of the Waorani community.

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