University of New Mexico

Neutrosophic Psychology of Teachers: Addressing Perceptions of Uncertainty and Motivation in the Implementation of Thinking Strategies

Edward David Ticona Ponce [1*] , Adán Humberto Estela Estela [2] , Manuel Cesar Vildoso Villega [3] , Pierre Sean Rojas Padilla [4] , Virgilio Vildoso Gonzales [5] , Hortencio Flores Flores [6] , and Carlos Fretel Martínez [7]

[1] Universidad Nacional Mayor de San Marcos, Lima, Peru. e1729392@gmail.com
[2] Universidad Nacional Mayor de San Marcos, Lima, Peru. aestelae@unmsm.edu.pe
[3] Universidad Nacional Jorge Basadre Grohmann, Avenida Miraflores s/n, Ciudad Universitaria, Tacna, Perú. mvildosov@unjbg.edu.pe
[4] Instituto Latinoamericano de Empresas y Negocios (ILEN), Lima, Peru. projas@ilen.edu.pe
[5] Jorge Basadre Grohmann National University, Avenida Miraflores s/n, Ciudad Universitaria, Tacna, Peru. vvildosog@unjbg.edu.pe
[6] Universidad Nacional Jorge Basadre Grohmann, Avenida Miraflores s/n, Ciudad Universitaria, Tacna. Peru. flores@une.edu.pe
[7] Universidad Nacional Mayor de San Marcos, Lima, Peru. cfretelm_af@unmsm.edu.pe

Abstract. This study addresses a key challenge in contemporary education: teachers' psychological resistance to implementing critical thinking strategies, a problem compounded by ambivalent perceptions, indeterminate motivations, and a lack of tools to measure these complexities. Although previous research has explored pedagogical barriers, little has examined the subjective and inconsistent dimension of teachers' attitudes, leaving a gap in our understanding of how uncertainty affects the adoption of educational innovations. To address this, the article proposes a framework based on Neutrosophic Psychology, which quantifies contradictions in teachers' beliefs (such as the coexistence of genuine motivation and external pressures) using neutrosophic numbers, applying adaptive surveys and indeterminacy analysis. The results reveal that teachers exhibit significant degrees of ambivalence—for example, they value active methodologies but doubt their self-efficacy—a finding that traditional binary methods would not capture. This research contributes theoretically by integrating neutrosophic logic into educational psychology, offering a more realistic model of teacher decision-making, while, in practice, suggesting differentiated training that addresses not only technical knowledge but also emotional gray areas. Thus, the study transcends diagnosis, proposing strategies to transform uncertainty into a driver of educational change.

Keywords: Neutrosophic Psychology, Critical Thinking, Teacher Motivation, Educational Uncertainty, Pedagogical Strategies, Teacher Training, Neutrosophic Logic.

1. Introduction

The development of critical thinking in education has been positioned as a fundamental priority in recent decades, recognized as an essential competence to face the challenges of today's society [1]. This growing interest is supported by evidence that links critical thinking with better academic results, greater analytical capacity, and more informed decision-making [2]. However, the effective implementation of strategies for its development faces significant obstacles, particularly related to psychological and attitudinal factors of teachers. From a historical perspective, the teaching of critical thinking has evolved from approaches focused on formal logic to more comprehensive models that incorporate cognitive,

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metacognitive, and dispositional dimensions [3]. This paradigmatic shift has generated new demands on teachers, who must now master not only disciplinary content, but also innovative pedagogical methodologies. However, recent research indicates that many teacher training programs fail to adequately prepare teachers for this complex task [4].

The core of the problem lies in the gap between institutional expectations for the teaching of critical thinking and the psychological realities teachers face in their daily practice. How do teachers perceive their ability to foster critical thinking? What motivational factors facilitate or hinder the implementation of effective strategies? These questions are particularly relevant when considering that teachers' attitudes are frequently ambiguous, contradictory, or subject to uncertainty. The specialized literature has partially addressed these issues, mainly through studies using traditional measurement scales [5]. However, these conventional approaches have significant limitations when attempting to capture the complex and multidimensional nature of teachers' perceptions. Particularly problematic is the inability of these instruments to adequately represent psychological states that are neither completely positive nor completely negative, but rather contain significant degrees of ambivalence and indeterminacy. To overcome these limitations, this study proposes an innovative conceptual framework based on Neutrosophic Psychology, which allows analyzing teachers' perceptions as complex systems where elements of certainty, indeterminacy and contradiction coexist [6]. This approach is particularly suitable for the study of educational phenomena, where human attitudes are rarely univocal or completely consistent.

Methodologically, the research combines qualitative and quantitative techniques tailored to capture the complexity of teachers' perceptions. Specially designed instruments are used to identify and quantify the varying degrees of certainty, doubt, and contradiction present in attitudes toward the teaching of critical thinking. This approach overcomes the limitations of traditional methods, which force categorical responses to phenomena that are inherently gradual. The main objectives of this study are: (1) to analyze teachers' perceptions of their ability to teach critical thinking using a neutrosophic framework; (2) to identify the main factors that generate uncertainty and ambivalence in teachers regarding the implementation of strategies for developing critical thinking; and (3) to propose guidelines for the design of teacher training programs that explicitly consider the complex nature of teachers' attitudes and perceptions.

2. Preliminaries
2.1. Strategies for Critical Thinking: Review and considerations

The development of critical thinking (CT) in education has ceased to be a pedagogical option and has become a pressing need in increasingly complex and information-inundated societies [7]. However, its effective implementation faces structural obstacles that go beyond the mere transmission of analytical techniques, requiring a profound rethinking of traditional educational models. Despite its recognized importance, why is it still so difficult to integrate CT transversally into educational systems?

Historically, strategies for fostering CT have oscillated between two extremes: reductionist approaches that equate it with formal logical skills, and overly broad positions that dilute it into vague concepts such as "good judgment" [8]. This lack of operational consensus has generated confusion among teachers, many of whom lack specific training to implement effective methodologies. Paradoxically, while students are required to think critically, this same requirement is rarely applied to the design of pedagogical strategies aimed at cultivating it. A detailed analysis reveals that the main limitations lie not in the lack of available techniques, but in three interrelated factors: insufficient teacher training, the pressure to cover extensive curricular content, and standardized assessment that rewards reproduction over analysis [9]. These elements form a vicious circle where the most innovative strategies are relegated by traditional practices that, although less effective, seem "safer" in the face of obsolete measurement systems.

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Recent research indicates that the most successful strategies share four fundamental characteristics: they are explicit in their CT objectives, they are vertically integrated into the curriculum, they encourage metacognition, and they create spaces for authentic questioning [10]. Examples such as structured debate, real-life case analysis, or critical evaluation of sources demonstrate greater effectiveness than abstract or decontextualized approaches. However, their implementation requires conditions that many institutions do not provide: time for reflection, curricular flexibility, and sustained institutional support. From a critical perspective, it is worth questioning whether many supposed "CT strategies" are nothing more than superficial recycling of old practices with new terminology. The mere fact of including "critical" questions in an assessment or holding class discussions does not guarantee the genuine development of these skills. Even worse, some methodologies promoted as innovative may actually reproduce power dynamics where only certain types of thinking are validated as "critical" [11]. Evaluating the real impact of these strategies presents significant methodological challenges. While some studies report modest improvements in specific skills, others find that benefits do not transfer across domains or persist long-term [12]. This inconsistency suggests that CT is not a unitary competency that can be developed through isolated interventions, but rather a set of dispositions and skills that require ongoing cultivation across diverse contexts.

An often neglected aspect is the emotional and motivational dimension of CT. Emerging research highlights that factors such as tolerance for ambiguity, intellectual curiosity, and resistance to conformity play roles as important as cognitive skills [13]. However, few strategies systematically incorporate these elements, focusing almost exclusively on rational aspects. Technological integration offers both opportunities and risks for the development of CT. On the one hand, digital tools allow access to diverse perspectives and analysis of information at scales previously unthinkable; on the other, information overload and filtering algorithms can reinforce biases and superficial thinking [14]. The most promising strategies are those that do not simply use technology, but also teach how to critically question it. In summary, effective strategies for CT require abandoning the search for "magic formulas" and adopting systemic approaches that consider: (1) specialized teacher training, (2) curricular coherence, (3) authentic assessment, and (4) the cultivation of intellectual dispositions. Their assessment must go beyond immediate measurements, considering long-term impacts on students' intellectual autonomy.

2.2 Neutrosophic psychology: basic concepts

This section is dedicated to summarizing the main concepts and methods of the Theory of Neutrosophic Psychology.

In [15] Smarandache refers to Sigmund Freud who divides memory into: conscious, preconscious and unconscious. In the framework of neutrosophic psychology it is defined as a third state called " aconscious ", which means: being ignorant, impassive, indifferent, insensitive and unfeeling.

Similar to neutrosophic theory, neutrosophic psychology deals with concepts represented by (<A>, <neutA> , <antiA>) , one of which is described below[16, 17]:

1) Conscious, i.e. things we are currently aware of, corresponds to <A>.
2) Unconscious, which includes things we are not aware of and which are difficult to access because they are located deep within our mind. It is the opposite of the conscious and corresponds to < antiA >.
3) Unconscious, which etymologically means distant from the conscious and the unconscious, or neither conscious nor unconscious, but intermediate, or a mixture of the conscious and the unconscious, a vague intermediate zone between the two. It corresponds to < neut A> or Indeterminacy, as in Neutrosophy.

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Thus, consciousness, unconsciousness, and unconsciousness are the sources of positive, neutral (or combined), and negative emotions, thoughts, and behaviors throughout our lives.

In human behavior, there is a constant interaction and discussion between the conscious, the unconscious, and the unconscious. Sometimes people are predominantly rational, sometimes they are predominantly irrational, and sometimes they are indifferent.

The triple $(<A>, <neut\ A>, <antiA>)$ extends to *discrete refined neutrosophic memory* , where $(<A>_1, <A>_2, ..., <A>_l; <neutA>_1, <neutA>_2, ..., <neutA>_m; <antiA>_1, <antiA>_2, ..., <antiA>_n)$ they are defined in terms of refined neutrosophy, see [18,19].

Also Smarandache in [15] quotes Carl Jung who divided the unconscious into ([20]):

- The personal unconscious, which is specific to each individual and includes forgotten or suppressed consciousness;
- The collective unconscious, characteristic of the entire human species, is made up of ancestral memories called "archetypes" (images of universal meaning) and mental patterns as inherited psychic structures.

Smarandache adds the group unconscious, which is:

- Group unconsciousness, which lies between the personal and collective unconscious. It is characteristic of a specific group to which an individual belongs and has significantly influenced them.

Equivalently, it extends Jung's personal and collective consciousness to group consciousness.

Aconsciousness has a degree of conscious (c), and a degree of unconsciousness (u), where $c \in [0,1]$, and $0 \le c + u \le 2$.

In neutrosophic psychology the following notation exists:

NL(entity) $= (c, a, u)$ (1)

Where c = degree of consciousness (truth), a = degree of non-consciousness (indeterminacy): I am not sure if it is conscious or unconscious, or a mixture of both, and u = degree of unconsciousness (falsehood), while NL is the notation for the semantics of neutrosophic logic ([19, 20]).

NL(conscious) $= (1, 0, 0)$; NL(acounscious) $= (0, 1, 0)$; and NL(unconscious) $= (0, a, 1)$, where a $\in (0, 1]$, leaving room for indeterminacy (unknown, unclear).

Given U a universe of discourse, subsets A, B and C, then the Crisp Neutrosophic Set of Type 2 satisfies the axioms: $A \cap B = \emptyset$, $B \cap C = \emptyset$, $C \cap A = \emptyset$ and $A \cup B \cup C = U$. Therefore, A, B, C form a disjoint partition of the universe of discourse U.

The crisp refined neutrosophic set of type 2 (and similarly for types 1 and 3) is defined as [21]: $A = A_1 \cup A_2 \cup ... \cup A_p$, $B = B_1 \cup B_2 \cup ... \cup B_r$, $C = C_1 \cup C_2 \cup ... \cup C_s$, with $A \cap B = B \cap C = C \cap A = \emptyset$, where p, r, s are integers ≥ 1, $p + r + s \ge 4$, and $A_i \cap A_j = \emptyset$ for $i, j \in \{1,2,...,p\}$, $i \ne j$; $B_k \cap B_l = \emptyset$ for $k, l \in \{1,2,...,r\}$, $k \ne l$; and $C_m \cap C_n = \emptyset$ for $m, n \in \{1,2,...,s\}$, $m \ne n$.

Neutropsychic Personality Crisp considers the human person as a universe of discourse U, and three disjoint sets which are the following ([22]) :

E = set of emotions of this person;

H = set of thoughts of this person;

B = set of behaviors of this person.

Therefore, $U = E \cup H \cup B$, with $E \cap H = \emptyset$, $H \cap B = \emptyset$, and $B \cap E = \emptyset$. Therefore, $U = <E, H, B>$.

Furthermore, the trait is measured by degrees of <trait> and degrees of <antitrait>, so that each person

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is classified on a range between these two opposites and is dynamic. They also include an intermediate position where there is uncertainty.

The most common trait-antitrait pairs are the following [23]:

- Extraversion – Introversion
- Consciousness – Unconsciousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensibilism
- Novator – Conservative
- Self-esteem – Self-esteem not
- Kindness – Dislike
- Openness to intellect and experience – Closeness to intellect and experience
- Inhibition – Disinhibition
- Flexibility – Rigidity
- Emotivism [Neuroticism (Hans Eysenck)] – Non- emotivism
- Obsession – Not obsession
- Caution – Impulsiveness
- Shyness – Boldness
- Honesty – Dishonesty
- Hostility [Psychoticism (Hans Eysenck)] – Non-hostility.

The *neutrosophic trait operator* is the cumulative degree of individual x with respect to both the Trait and the antiTrait , and is defined as:[24]

$$d_{Trait\&antiTrait}: S \rightarrow [-1, 1] \quad (2)$$

Where, $d_{Trait \& antiTrait}(x) = d_{Trait}(x) + d_{antiTrait}(x)$.

To classify an individual as belonging to the trait or the anti-trait, a threshold is defined and denoted by Thr for the trait and antiThr for the anti-trait, such that:

- If $d_{Trait\&antiTrait}(x) \geq +Thr$, then the individual is classified as definitely belonging to the Trait,
- *If $d_{Trait\&antiTrait}(x) \leq -antiThr$, then the individual is categorized as definitely belonging to the antiTrait.*
- *If $d_{Trait\&antiTrait}(x) \in (-\varepsilon, +\varepsilon)$, then the individual is classified as being in a totally indeterminate state between the Trait and the anti-Trait.*
- *If $d_{Trait\&antiTrait} \in (\varepsilon, Thr)$, then the individual is classified as belonging mostly to the Trait.*
- *If $d_{Trait\&antiTrait}(x) \in (-antiThr, -\varepsilon)$, then the individual is classified as belonging mostly to the anti-Trait.*

The way to deal with $d_{Trait\&antiTrait}$ It is illustrated as follows:

"Suppose a psychiatrist, after many sessions, neutrosophic questionnaires, and observations measured with neutrosophic statistics, has come to the conclusion that the two dimensions of George P.'s temperament are estimated with some precision as:

- The degree of stability (trait) is $d_{GP}(stable) = 0.2 \in [0, 1]$,
- The degree of instability (antitrait) is $d_{GP}(unstable) = -0.5 \in [-1, 0]$; and

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- The degree of extroversion (trait) is $d_{GP}(extroverted) = 0.9 \in [0,1]$,
- The degree of introversion (antitrait) is $d_{GP}(introverted) = -0.3 \in [-1,0]$.

So $d_{GD<stable>\&<unstable>}(x) = d_{GP(stable)} + d_{GP(unstable)} = 0.2 + (-0.5) = -0.3$, and $d_{GD<extroverted>\&<introverted>}(x) = d_{GP(extroverted)} + d_{GP(introverted)} = 0.9 + (-0.3) = +0.6$."

3. Methodology.

Critical thinking represents a fundamental competency in 21st-century education, defined as the ability to analyze, evaluate, and synthesize information in a reflective and systematic manner. It encompasses cognitive skills such as interpretation, analysis, evaluation, inference, explanation, and self-regulation. In the educational context, teachers face the challenge of transforming traditional methodologies into approaches that foster these higher-order thinking skills.

The implementation of critical thinking strategies requires teachers to adopt the role of learning facilitators, promoting questioning, reflection, and critical analysis. However, this pedagogical transition creates tensions between traditional beliefs about teaching and the demands of educational innovation.

Neutrosophic Psychology Applied to Education

Neutrosophic psychology, developed by Smarandache (2018), extends traditional psychological concepts by explicitly incorporating indeterminacy as a valid psychological state. In the educational context, this means recognizing that teachers can simultaneously experience:

- **Motivation (m):** Genuine enthusiasm for pedagogical innovation
- **Indetermination (i):** Ambivalence, doubts or mixed states of confidence
- **Resistance (r):** Fears, rejection or demotivation towards change

The neutrosophic representation of teaching attitudes is expressed as:

$$NL(actitud\_docente) = (m, i, r)$$

Where **m** = degree of motivation, **i** = degree of indeterminacy, and **r** = degree of resistance, with $m, i, r \in [0,1]$ y $0 \leq m + i + r \leq 3$.

Study Design

A descriptive-correlational design was implemented using a neutrosophic approach for data analysis. The target population was secondary school teachers from public and private institutions.

Sample Calculation

The student population consisted of 850 teachers. Using the simple random sampling formula:

$$n = \frac{Nz^2 pq}{d^2(N-1) + z^2 pq} \quad (3)$$

Where:

- N = 850 (population size)
- z = 1.96 (95% confidence level)
- p = q = 0.5 (maximum variability)

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- d = 0.05 (allowable error of 5%)

$$n = (850 \times 1.96^2 \times 0.5 \times 0.5) / (0.05^2 \times (850 - 1) + 1.96^2 \times 0.5 \times 0.5) \approx 265 \ docentes$$

Variables Measured

A neutrosophic questionnaire was designed with 8 key variables:

- **V_1:** Confidence in critical thinking methodologies (Very high, High, Medium, Low, Very low)
- **V_2:** Perception of teacher self-efficacy (Very competent, Competent, Moderately competent, Slightly competent)
- **V_3:** Attitude towards pedagogical innovation (Very positive, Positive, Neutral, Negative)
- **V_4:** Intrinsic motivation for change (Very high, High, Medium, Low)
- **$V5$:** Anxiety about new methodologies (Never, Rarely, Sometimes, Frequently, Always)
- **V_6:** Perceived institutional support (Excellent, Good, Fair, Poor)
- **V_7:** Resistance to methodological change (Zero, Low, Medium, High, Very high)
- **V_8:** Conceptual clarity on critical thinking (Very clear, Clear, Somewhat clear, Confusing, Very confusing)

4. Results.

The responses were classified according to the neutrosophic framework into three categories:

- **<M>** (Motivation): Responses that indicate a positive disposition toward critical thinking
- **< Neut M>** (Indeterminacy): Responses that reflect ambivalence or mixed states
- **<Anti M>** (Resistance): Responses that show opposition or lack of motivation

3.2. Survey Data

Table 1: Percentage Distribution of Teacher Attitudes by Neutrosophic Categories (Motivation, Indeterminacy, Resistance)

Variable	<M>	< Neut M>	<Anti M>
V_1 - Methodological confidence	42%	28%	30%
V_2 - Teacher self-efficacy	38%	35%	27%
V_3 - Innovation attitude	55%	18%	27%
V_4 - Intrinsic Motivation	48%	24%	28%
V5 - Methodological anxiety	25%	22%	53%
V_6 - Institutional support	33%	31%	36%
V_7 - Resistance to change	29%	26%	45%
V_8 - Conceptual clarity	41%	32%	27%

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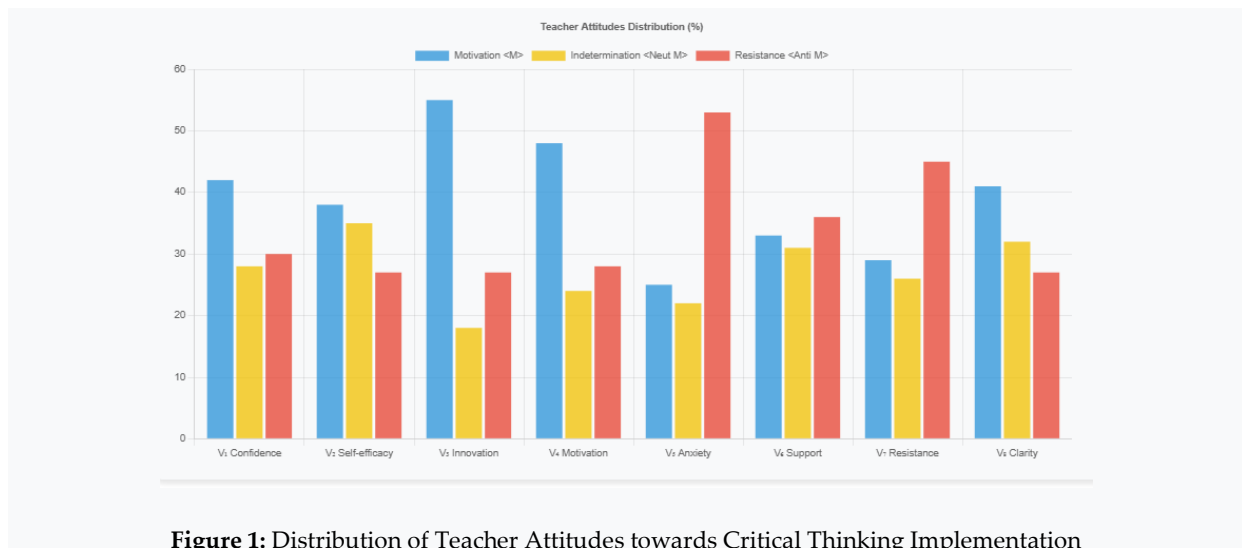
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Figure 1: Distribution of Teacher Attitudes towards Critical Thinking Implementation

Neutrosophic Processing

The data were processed by applying the bipolar neutrosophic operator:

Table 2. Calculation of the Bipolar Neutrosophic Index d (M&Anti M) for each Study Variable.

Variable	<M>	< Neut M>	<Anti M>	d(M&Anti M)
V_1	+0.42	0.28	-0.30	0.12
V_2	+0.38	0.35	-0.27	0.11
V_3	+0.55	0.18	-0.27	0.28
V_4	+0.48	0.24	-0.28	0.20
V5	+0.25	0.22	-0.53	-0.28
V_6	+0.33	0.31	-0.36	-0.03
V_7	+0.29	0.26	-0.45	-0.16
V_8	+0.41	0.32	-0.27	0.14
Aggregate Result	**+0.389**	**0.270**	**-0.341**	**0.048**

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General Neutrosophic Index: $d_{(}M\&Anti\ M_{)} = 0.048$

This result indicates a state of **critical indeterminacy** in teachers' attitudes toward the implementation of critical thinking strategies.
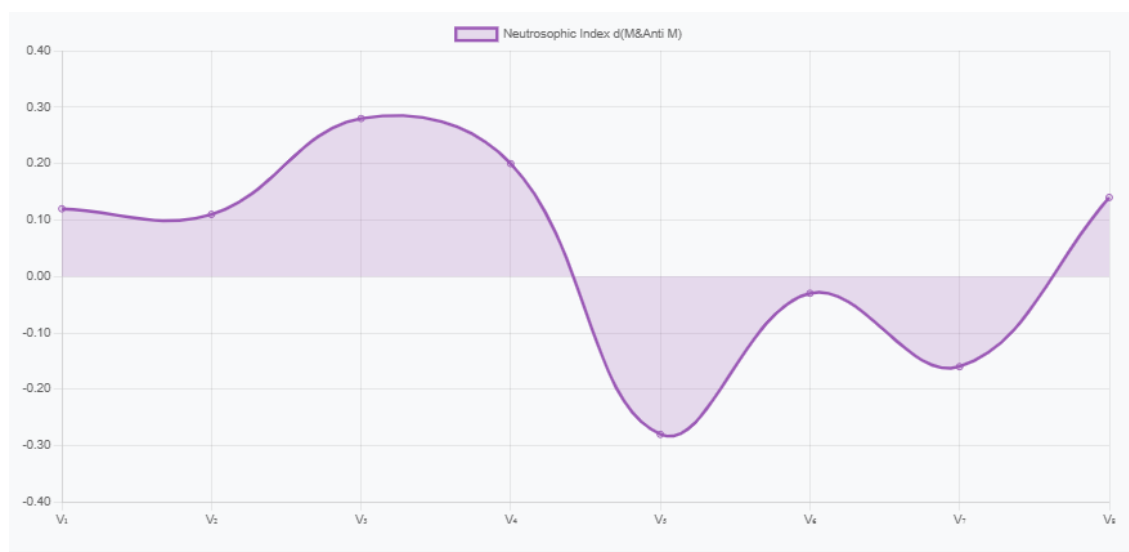

Figure 2: Neutrosophic Analysis of Teacher Variables

Analysis by Neutrosophic Thresholds

- Upper threshold for motivation (Thr): >+0.25
- Lower threshold for resistance (antiThr): <−0.25
- Range of uncertainty (ϵ): [− 0.05,+0.05]

Classification of Variables with Adjusted Thresholds:
Variables with a marked motivational tendency (d≥+0.25):

- V_3 (Attitude towards innovation): d=0.28

Variables with a mostly motivational tendency (+0.05<d<+0.25):

- V_1 (Methodological confidence): d=0.12
- V_2 (Teacher self-efficacy): d=0.11
- V_4 (Intrinsic Motivation): d=0.20
- V_8 (Conceptual Clarity): d=0.14

Variables in a totally indeterminate state (−0.05≤d≤+0.05):

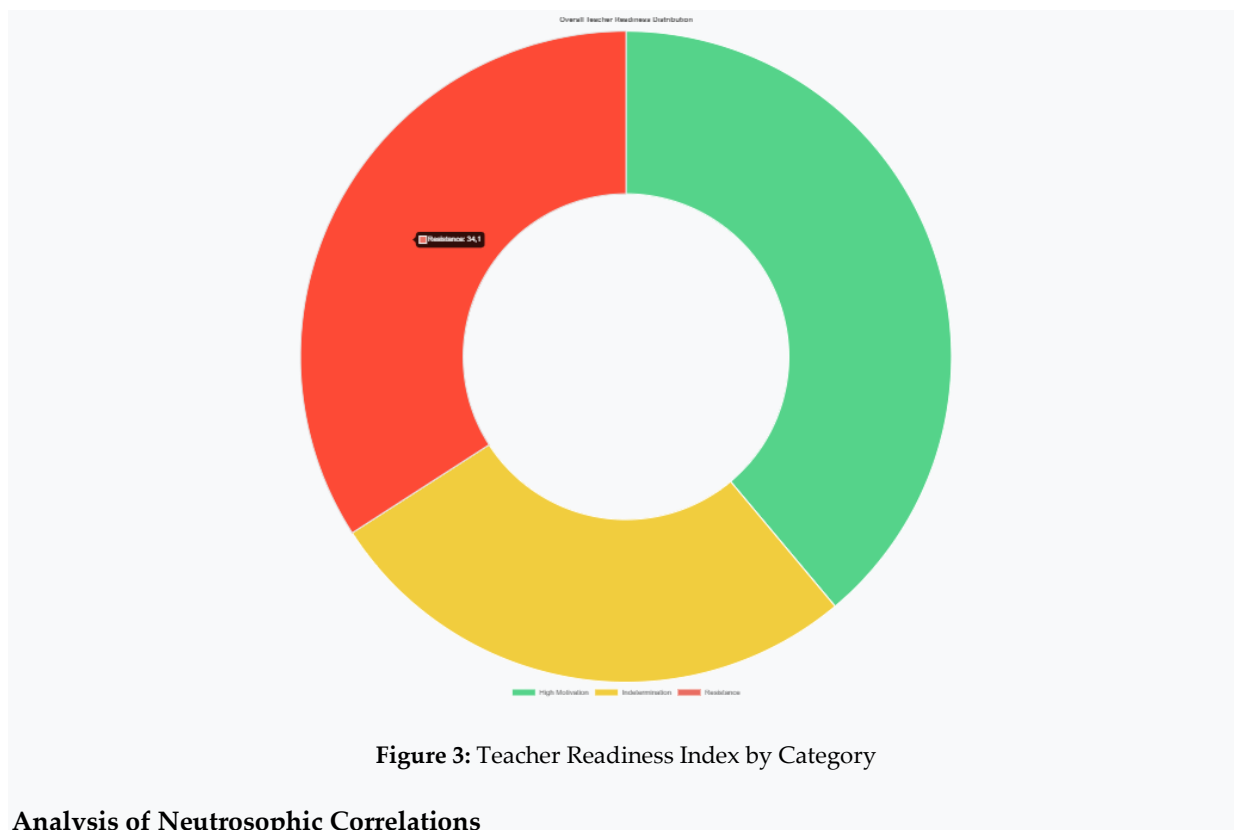- V_6 (Institutional support): d=−0.03

Variables with a mostly resistant trend (−0.25<d<−0.05):

- V_7 (Resistance to change): d=−0.16

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Variables with a markedly resistant trend (d≤−0.25):

- V_5 (Methodological anxiety): d=−0.28

Figure 3: Teacher Readiness Index by Category

Analysis of Neutrosophic Correlations

Significant patterns of indeterminacy were identified [25]:

Table 3: Correlation Analysis between Key Psychological Variables of Teachers.

Correlation	Coefficient	Neutrosophic Interpretation
Self-efficacy ↔ Anxiety	-0.68	High reciprocal indeterminacy
Institutional support ↔ Motivation	+0.72	External motivational dependence
Conceptual clarity ↔ Confidence	+0.65	Cognitive indeterminacy

Interpretation of Results

The aggregate neutrosophic index of **0.048** reveals a critical state of indeterminacy in teachers' attitudes. This result transcends the limitations of traditional binary analyses by capturing the inherent complexity of teachers' perceptions.

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Key Findings:

- **Motivational paradox:** High interest in innovation (55%) but low self-efficacy (38%)
- **Methodological anxiety:** Main barrier identified (53% in resistant category)
- **Institutional dependence:** Motivation is significantly correlated with perceived support

Theoretical Implications

This study contributes to the field of educational psychology by demonstrating that:

1) Teachers' attitudes towards innovation are not dichotomous but **three-dimensional.**
2) Indeterminacy represents a **valid psychological state** that requires specific interventions
3) Neutrosophic models provide a **more realistic representation** of human complexity.

Recommendations

Differentiated Training Strategies

For Teachers in a Motivational State$(d > +0.2)$:

- Methodological deepening programs
- Pedagogical leadership roles
- Communities of Advanced Practice

For Teachers in Indeterminacy$(-0.2 \leq d \leq +0.2)$:

- Personalized accompaniment
- Gradual implementation experiences
- Strengthening self-efficacy
- Structured conceptual clarification

For Teachers with Resistance$(d < -0.2)$:

- Specific motivational interventions
- Reduction of methodological anxiety
- Practical demonstrations of benefits
- Strengthened institutional support

Institutional Guidelines

- **Initial neutrosophic diagnosis** before implementing training programs
- **Differentiated support systems** according to the teacher's neutrosophic profile
- **Continuous monitoring** of the evolution of teaching attitudes
- **Institutional culture** that values uncertainty as an opportunity for growth

5. Conclusions.

This pioneering study on the application of neutrosophic psychology to the analysis of teaching attitudes reveals a complex reality that traditional approaches often oversimplify. The primary conclusion is that teachers' perceptions regarding the implementation of critical thinking strategies are not

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predominantly positive or negative, but are fundamentally characterized by indeterminacy. This state of uncertainty and ambivalence is directly influenced by critical factors such as anxiety surrounding new pedagogical challenges and the perception of institutional support, both of which emerge as variables requiring priority attention. The neutrosophic framework has proven to be a more precise and human tool for capturing this complexity, validating uncertainty as a natural component of the teaching attitude. The fundamental contribution of this research transcends conventional diagnosis by proposing a three-dimensional model of psychological analysis that legitimizes indeterminacy as a valid and, above all, transformable state. By recognizing that teachers are not always situated at defined poles of acceptance or rejection, new and significant possibilities for pedagogical intervention are opened. This approach allows for the design of more effective and humanized teacher training programs that do not merely seek to eradicate negative perceptions, but instead work constructively with indeterminacy to guide educators toward a more confident and reflective adoption of critical thinking strategies, thereby strengthening their professional practice from a deeper understanding of their realities.

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