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A Neutrosophic Framework for Nursing Education Quality Analysis Using Upside-Down Logics and Narrative Factor

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Abstract: Evaluating the quality of nursing education is challenging due to subjective and conflicting assessments from students, instructors, and administrators. Traditional methods, such as numerical grades, often fail to capture the uncertainty and differing perspectives in these evaluations. This study introduces a new mathematical model based on Neutrosophic Logic and Upside-Down Logics to address these issues. Neutrosophic Logic allows for the simultaneous representation of truth, falsehood, and indeterminacy, while Upside-Down Logics model how evaluations can shift between positive and negative depending on context. We also propose a Narrative Factor to quantify the impact of personal biases and cultural influences. The model includes clear equations and a practical application in a clinical simulation, demonstrating how it identifies uncertainty and bias in student evaluations. This framework offers a robust, flexible tool for improving the fairness and accuracy of nursing education assessments, with potential applications in other educational settings.

Keywords: Neutrosophy, Upside-Down Logics, Nursing Education, Quality Analysis, Uncertainty, Narrative Factor

1. Introduction and Literature Review

Nursing education is a cornerstone of healthcare, equipping future professionals with the practical skills, cultural sensitivity, and critical thinking necessary for effective practice. However, evaluating the quality of nursing education is fraught with challenges due to the subjective nature of assessments. Stakeholders such as students, instructors, and administrators often hold divergent views on the same performance. For example, one instructor might praise a student's clinical reasoning as "strong," while another might critique it as "inadequate." Similarly, students may contest faculty evaluations of training quality, leading to uncertainty and contradictions in the assessment process. Traditional evaluation tools, such as numerical grades or standardized rubrics, often fail to capture this complexity, as they prioritize a single, definitive judgment over multiple, conflicting perspectives [1].

To address these limitations, this study proposes a novel approach grounded in Neutrosophy and Upside-Down Logics, concepts pioneered by Smarandache [2, 3]. Neutrosophy offers a mathematical framework that accommodates truth, falsehood, and indeterminacy simultaneously, making it well-suited for handling the ambiguity inherent in educational evaluations [2]. Upside-Down Logics, encompassing "falsification of the truth" and "truthification of the false," provide strategies to reframe statements by altering their context, attributes, or logic [4]. These concepts are particularly relevant in nursing education, where subjective interpretations and narrative factors shape perceptions of quality. This paper develops a mathematically rigorous model that integrates:

1. A neutrosophic framework to evaluate multiple attributes with inherent uncertainties.
2. A formal Upside-Down operator to systematically invert truth and falsehood in evaluations.
3. A Narrative Factor to quantify the influence of personal interpretations.
4. Explicit equations and examples to ensure clarity and precision.

The literature on nursing education quality assessment highlights the need for methods that embrace subjectivity and conflicting perspectives. Neutrosophy, introduced by Smarandache in 1998, provides a robust philosophical and logical system for this purpose [2, 3]. Unlike binary logic, which forces statements into true or false categories, Neutrosophy incorporates a neutral or indeterminate state, allowing for partial truth and partial falsehood [2]. This is critical in nursing education, where evaluations often blend positive, negative, and ambiguous elements. For instance, Smarandache describes Neutrosophy as modeling the dynamics between opposites (,) and their neutral states (), such as "effective teaching" (positive), "ineffective teaching" (negative), and indeterminate assessments in between [2, 3]. This framework has been applied in fields like decision-making and artificial intelligence, but its potential in educational assessment remains underexplored [2].

Smarandache's Upside-Down Logics further enhance this framework by offering techniques to transform truth into falsehood or vice versa through contextual shifts [4]. For example, a true statement like "1 = 1" can be falsified as "1 meter = 1 kilometer" by changing measurement units, while a false statement like "2 = 1" can be truthified as "2 pints = 1 quart" through appropriate attributes [4]. These transformations, achieved through strategies like altering space, time, or logic, are particularly relevant in social sciences, including education, where subjective narratives can reshape perceived truths [4]. In nursing education, such methods can help analyze how differing stakeholder perspectives alter the perceived quality of teaching or clinical training.

The application of Neutrosophy in decision-making contexts, as explored by Rivieccio, demonstrates its utility in handling complex, subjective data, which is directly applicable to educational assessments [5]. Rivieccio's work emphasizes how neutrosophic logic can model multi-criteria decision-making, providing a precedent for evaluating diverse attributes in nursing education [5]. Similarly, the exploration of neutrosophic sets by Wang et al. offers a mathematical foundation for quantifying indeterminacy, supporting the development of a Narrative Factor to capture personal stories in educational evaluations [6]. These studies underscore the versatility of neutrosophic approaches in addressing ambiguity, a key challenge in nursing education quality analysis.

Despite the promise of Neutrosophy and Upside-Down Logics, their application in nursing education is novel. Current evaluation methods often rely on quantitative metrics, such as test scores or clinical checklists, which overlook the nuanced, subjective experiences of learners and educators [1]. By integrating Neutrosophy's ability to model indeterminacy, Upside-Down Logics' contextual flexibility, and a Narrative Factor to account for personal interpretations, this study offers a comprehensive framework for analyzing nursing education quality. This approach not only addresses the limitations of traditional methods but also aligns with the complex, multifaceted nature of educational assessment.

2. Main Sets and Parameters

In this section, we present the precise mathematical structure that supports the proposed Neutrosophic Upside-Down Logic framework. This model rigorously combines multiple attributes, contradictory evaluations, and contextual narrative effects in the assessment of nursing education quality.

We begin by defining the core elements Let:

$$H = \{S_1, S_2, \ldots, S_n\}$$

represent the finite set of n students enrolled in a nursing course. Let:

$$A = \{A_1, A_2, \ldots, A_m\}$$

represent the finite set of m educational attributes that characterize the quality of learning outcomes.

Attributes may include:

$A_1 =$ clinical reasoning , $A_2 =$ ethical decision-making , $A_3 =$ team collaboration , ...

Each attribute A_i has an associated set of possible categorical values:

$$V_i = \{v_{i1}, v_{i2}, \ldots, v_{ip}\}$$

where each v_{ij} is a linguistic or numeric level of performance (e.g., "excellent," "satisfactory," or "insufficient").

Neutrosophic Evaluation Vectors

For each attribute A_i and student S_j, we define a neutrosophic evaluation vector:

$$N_i(S_j) = (T_{ij}, I_{ij}, F_{ij})$$

where:

$T_{ij} \in [0,1]$ quantifies the degree of truth or positive agreement regarding student S_j 's performance in attribute A_i.

$I_{ij} \in [0,1]$ quantifies the level of indeterminacy (e.g., incomplete data, subjective disagreement).

$F_{ij} \in [0,1]$ quantifies the degree of falsehood or negative disagreement.

We require:

$$0 \leq T_{ij} + I_{ij} + F_{ij} \leq 3$$

This formulation allows explicit partial memberships and reflects the complex overlap of agreement, uncertainty, and disagreement in subjective evaluations.

The Upside-Down Transformation

To formally capture the "Upside-Down" philosophical idea of reversing truth and falsehood in assessments, we define the Upside-Down Transformation operator:

$$U: [0,1]^3 \to [0,1]^3$$

such that:

$$U(T_{ij}, I_{ij}, F_{ij}) = (F_{ij}, I_{ij}, T_{ij})$$

This operator mathematically flips the degrees of truth and falsehood while preserving the indeterminacy component. It represents the process by which an assertion (or assessment) may be inverted due to bias, misinformation, or interpretive framing.

Incorporating the Narrative Factor

Recognizing the impact of personal interpretations and cultural contexts in nursing education, we introduce a Narrative Factor:

$$S_{ij} \in [0,1]$$

This factor modulates the extent to which the student's evaluation is influenced by subjective narratives, such as:

Biases in instructor feedback.

Patient-family perceptions.

Cultural beliefs about nursing practices.

A higher S_{ij} reflects stronger narrative or contextual distortion.

Extended Upside-Down Transformation

We define the Extended Upside-Down Transformation:

$$U_S: [0,1]^3 \times [0,1] \to [0,1]^3$$

by:

$$U_S(T_{ij}, I_{ij}, F_{ij}; S_{ij}) = \left(\min(1, F_{ij} + S_{ij}), I_{ij}, \max(0, T_{ij} - S_{ij})\right)$$

This operator adjusts the truth and falsehood components by the magnitude of the narrative factor S_{ij} :

Falsehood is amplified by S_{ij} (since narratives can elevate perceived falsehood).

Truth is diminished by S_{ij} (narratives can overshadow actual performance).

Indeterminacy remains unchanged as it represents inherent ambiguity rather than opinion-driven bias.

General Evaluation Function

For each student S_j, their overall neutrosophic performance vector across all attributes is defined as:

$$E(S_j) = \{N_1(S_j), N_2(S_j), \dots, N_m(S_j)\}$$

After applying narrative-adjusted Upside-Down transformations, the adjusted evaluation becomes:

$$E^*(S_j) = \{U_S(N_1(S_j); S_{1j}), \dots, U_S(N_m(S_j); S_{mj})\}$$

This defines a complete neutrosophic profile for each student that explicitly accounts for:
Inherent uncertainty in qualitative nursing education assessment.
The possibility of reversals of truth/falsehood (upside-down logic).
Contextual narrative influences.

Let's consider a simplified, original example involving a single attribute A_1 for clarity:
Attribute: Clinical reasoning (A_1).
Student: S_2.
Initial neutrosophic evaluation:
$N_1(S_2) = (0.6,0.3,0.1)$
60% agreement on strong clinical reasoning, 30% uncertainty, 10% disagreement.
Suppose the narrative factor $S_{12} = 0.2$ (moderate narrative influence). Applying the extended upside-down operator:

$$U_S(0.6,0.3,0.1;0.2) = (\min(1,0.1+0.2) = 0.3, 0.3, \max(0,0.6-0.2) = 0.4)$$

$$N_1^*(S_2) = (0.3,0.3,0.4)$$

This new vector quantifies how the narrative context reduces confidence in the truth of the performance and increases the perception of falsehood.
This robust mathematical framework, with fully explicit operators and clear variable definitions, ensures that the proposed model is rigorous, precise, and ready for application in further examples and real-world nursing education analysis.

3. Proposed Model

This section presents the complete, rigorous measured model step by step. It combines the neutrosophic evaluation framework with the Upside-Down operator and the narrative adjustment. The model is designed for quantitative analysis of the quality of nursing education, accounting for multiple attributes and potential contradictory influences.

3.1 Model Setup

Step 1: Definition of Core Sets, Let:

$$H = \{S_1, S_2, \dots, S_n\}$$

represent the set of students, Let:

$$A = \{A_1, A_2, \dots, A_m\}$$

represent the set of attributes relevant to nursing education performance.
Each attribute A_i has a set of possible categorical or quantitative levels:

$$V_i = \{v_{i1}, v_{i2}, \dots, v_{ip}\}$$

Step 2: Neutrosophic Evaluation Vectors
For each student S_j and attribute A_i, the initial neutrosophic evaluation is:

$$N_i(S_j) = (T_{ij}, I_{ij}, F_{ij})$$

where:
T_{ij} is the degree of positive truth regarding S_j 's performance in A_i.
I_{ij} is the degree of indeterminacy.
F_{ij} is the degree of negative falsehood.

We require:

$$0 \le T_{ij}, I_{ij}, F_{ij} \le 1 \text{ and } 0 \le T_{ij} + I_{ij} + F_{ij} \le 3$$

Step 3: Definition of Narrative Factor

Each evaluation $N_i(S_j)$ is influenced by a narrative factor:

$$S_{ij} \in [0,1]$$

where:

$S_{ij} = 0$: no narrative bias (purely objective).

$S_{ij} = 1$: complete narrative control over the evaluation.

3.2 The Extended Upside-Down Operator

The Upside-Down Operator (basic form) is defined as:

$$U\left(N_i(S_j)\right) = \left(F_{ij}, I_{ij}, T_{ij}\right)$$

This swaps truth and falsehood, preserving indeterminacy.

To incorporate narrative influences, we introduce the Extended Upside-Down Operator:

$$U_S\left(N_i(S_j); S_{ij}\right) = \left(\min\left(1, F_{ij} + S_{ij}\right), I_{ij}, \max\left(0, T_{ij} - S_{ij}\right)\right)$$

which mathematically models how narratives simultaneously reduce perceived truth and increase perceived falsehood.

3.3 Attribute-Level Adjusted Evaluation

Applying the extended operator to each attribute evaluation produces:

$$N_i^*(S_j) = U_S\left(N_i(S_j); S_{ij}\right)$$

This gives an adjusted neutrosophic evaluation vector that fully incorporates:

The original neutrosophic profile.

Upside-Down reversal potential.

Narrative influence quantitatively.

3.4 Student-Level Adjusted Evaluation

The complete evaluation profile for a student S_j across all attributes is:

$$E^*(S_j) = \{N_1^*(S_j), N_2^*(S_j), \dots, N_m^*(S_j)\}$$

This gives an adjusted neutrosophic evaluation vector that fully incorporates:

The original neutrosophic profile.

Upside-Down reversal potential.

Narrative influence quantitatively.

3.4 Student-Level Adjusted Evaluation

The complete evaluation profile for a student S_j across all attributes is:

$$E^*(S_j) = \{N_1^*(S_j), N_2^*(S_j), \dots, N_m^*(S_j)\}$$

This multidimensional neutrosophic profile enables comprehensive analysis of the student's performance and how it may be distorted by conflicting perceptions or narratives.

3.5 Class-Level Aggregation

For the entire class:

$$\mathcal{E}^*(H)=\bigcup_{j=1}^{n} E^*(S_j)$$

This represents the collective adjusted evaluations, reflecting the full neutrosophic landscape of the course, including contradictory judgments and personal biases.

3.6 Quantitative Measures of Indeterminacy and Narrative Distortion

Indeterminacy of Attribute-Level Evaluation

For each attribute A_i and student S_j :

$$\operatorname{Indet}(S_j, A_i)=I_{ij}$$

Higher values reflect ambiguity or disagreements about performance in that specific attribute.

Narrative Distortion Metric

We define a narrative distortion index:

$$D_{ij}=\left|T_{ij}-\left(T_{ij}-S_{ij}\right)\right|+\left|F_{ij}-\left(F_{ij}+S_{ij}\right)\right|$$
$$D_{ij}=S_{ij}+S_{ij}=2S_{ij}$$

This simple but rigorous expression shows that narrative distortion in the truth-falsehood components is directly proportional to twice the narrative factor.

Illustrative Numerical Example

Let us consider a new numerical example with no repetition from previous parts.

Attribute: Ethical decision-making (A_2)

Student: S_4

Initial neutrosophic evaluation: $N_2(S_4)=(0.5,0.4,0.1)$

Narrative factor: $S_{24}=0.25$

Step 1: Apply Extended Upside-Down Operator

New Falsehood $=\min(1,0.1+0.25)=0.35$

New Truth $=\max(0,0.5-0.25)=0.25$

Indeterminacy remains: 0.4

Final adjusted vector: $N_2^*(S_4)=(0.35,0.4,0.25)$

Step 2: Narrative Distortion Calculation

$D_{24}=2\times 0.25=0.5$

This numeric example explicitly demonstrates how the narrative factor shifts the perception of a student's ethical decision-making skill - increasing falsehood, decreasing truth, and leaving indeterminacy intact.

4. Practical Application

To illustrate the practical application of the proposed neutrosophic framework, we consider a group of four students (n=4) and two key attributes (m=2). This example uses new data to demonstrate the power and flexibility of the model while maintaining explicit mathematical clarity.

Setup

Students: $H=\{S_1,S_2,S_3,S_4\}$

Attributes: $A = \{A_1 =$ clinical reasoning, $A_2 =$ ethical decision-making $\}$

Initial Neutrosophic Evaluations

We define the neutrosophic evaluation vectors for each student and attribute as follows:

Student	$N_1(S_j) = (T_{1j}, I_{1j}, F_{1j})$	$N_2(S_j) = (T_{2j}, I_{2j}, F_{2j})$
S_1	(0.7, 0.2, 0.1)	(0.6, 0.3, 0.1)
S_2	(0.5, 0.4, 0.1)	(0.4, 0.5, 0.1)
S_3	(0.6, 0.3, 0.1)	(0.7, 0.2, 0.1)
S_4	(0.8, 0.1, 0.1)	(0.5, 0.4, 0.1)

Narrative Factors

For each student and attribute, we assign different narrative factors to represent diverse contextual biases:

Student	S_{1j}	S_{2j}
S_1	0.1	0.2
S_2	0.3	0.25
S_3	0.2	0.15
S_4	0.05	0.1

Adjusted Neutrosophic Evaluations

We apply the Extended Upside-Down Transformation to each evaluation vector:

For Student S_1 :

Attribute A_1 :

$$N_1^*(S_1) = (\min(1, 0.1 + 0.1) = 0.2, 0.2, \max(0, 0.7 - 0.1) = 0.6)$$

Attribute A_2 :

$$N_2^*(S_1) = (\min(1, 0.1 + 0.2) = 0.3, 0.3, \max(0, 0.6 - 0.2) = 0.4)$$

For Student S_2 :

Attribute A_1 :

$$N_1^*(S_2) = (\min(1, 0.1 + 0.3) = 0.4, 0.4, \max(0, 0.5 - 0.3) = 0.2)$$

Attribute A_2 :

$$N_2^*(S_2) = (\min(1, 0.1 + 0.25) = 0.35, 0.5, \max(0, 0.4 - 0.25) = 0.15)$$

For Student S_3 :

Attribute A_1 :

$N_1^*(S_3) = (\min(1, 0.1 + 0.2) = 0.3, 0.3, \max(0, 0.6 - 0.2) = 0.4)$

Attribute A_2 :

$N_2^*(S_3) = (\min(1, 0.1 + 0.15) = 0.25, 0.2, \max(0, 0.7 - 0.15) = 0.55)$

For Student S_4 :

Attribute A_1 :

$N_1^*(S_4) = (\min(1, 0.1 + 0.05) = 0.15, 0.1, \max(0, 0.8 - 0.05) = 0.75)$

Attribute A_2 :

$N_2^*(S_4) = (\min(1, 0.1 + 0.1) = 0.2, 0.4, \max(0, 0.5 - 0.1) = 0.4)$

Narrative Distortion Indices

For completeness, we compute the narrative distortion for each evaluation:

$$D_{ij} = 2S_{ij}$$

Student	D_{1j}	D_{2j}
S_1	0.2	0.4
S_2	0.6	0.5
S_3	0.4	0.3
S_4	0.1	0.2

This thorough numeric example demonstrates:
The explicit calculations for each operator at the attribute level.
How narrative factors quantitatively shift truth and falsehood components.
The resulting neutrosophic profiles that highlight contradictions and biases in performance evaluation.

Class-Level Evaluation Profiles

The adjusted neutrosophic evaluations for all students form a structured data set:

$$\mathcal{E}^*(H) = \{E^*(S_1), E^*(S_2), E^*(S_3), E^*(S_4)\}$$

Each student's profile:

$$E^*(S_j) = \{N_1^*(S_j), N_2^*(S_j)\}$$

where:

$$N_i^*(S_j) = (T_{ij}^*, I_{ij}^*, F_{ij}^*)$$

This explicit structuring enables direct comparisons of the neutrosophic components across the class.

Indeterminacy Distribution

For each student and attribute, the indeterminacy values are:

Student	I_{1j}^*	I_{2j}^*
S_1	0.2	0.3
S_2	0.4	0.5
S_3	0.3	0.2
S_4	0.1	0.4

Student S_2 has the highest indeterminacy across both attributes.
Student S_4 shows low indeterminacy in clinical reasoning but higher indeterminacy in ethical decisionmaking.
This identifies students whose evaluations are most affected by conflicting or ambiguous opinions essential for educators seeking to provide targeted support.

Narrative Distortion Quantification

The narrative distortion index $D_{ij} = 2S_{ij}$ explicitly quantifies the extent of narrative influence:
Student S_2 again shows the highest distortion levels, suggesting that narrative factors strongly shape perceptions of this student's performance.
Student S_4 has minimal narrative distortion in clinical reasoning ($D_{1,4} = 0.1$) but moderate in ethical decision-making.

Truth-Falsehood Shifts

The magnitude of change in truth and falsehood due to the Extended Upside-Down Operator can be measured by:

$$\Delta T_{ij} = T_{ij} - T_{ij}^{*} = S_{ij}$$
$$\Delta F_{ij} = F_{ij}^{*} - F_{ij} = S_{ij}$$

These simple linear relations (proportional to S_{ij}) confirm that narrative distortion shifts are mathematically predictable.

For example:

For Student S_2 and attribute A_1 :

$$\Delta T_{1,2} = 0.3, \Delta F_{1,2} = 0.3$$

For Student S_4 and attribute A_1 :

$$\Delta T_{1,4} = 0.05, \Delta F_{1,4} = 0.05$$

Mathematical Consistency and Implications

Linearity:

The Extended Upside-Down transformation is linear in the narrative factor:

$$T_{ij}^{*} = T_{ij} - S_{ij}, F_{ij}^{*} = F_{ij} + S_{ij}$$

This ensures mathematically robust behavior suitable for further generalizations.

Boundedness:

All final values $T_{ij}^{*}, I_{ij}^{*}, F_{ij}^{*}$ remain within [0,1], ensuring consistency and validity of the neutrosophic representation.

Interpretability:

Each component (T^{*}, I^{*}, F^{*}) directly reflects specific cognitive or social processes in the evaluation of nursing education:

T^{*} : confidence in performance.

I^{*} : persistent uncertainty.

F^{*} : degree of perceived failure or weakness.

Educational Implications

In nursing education:

1. Attributes with high indeterminacy indicate areas needing clearer standards or improved training methods.
2. Attributes with high narrative distortion suggest that social or cultural biases strongly affect assessments valuable for bias mitigation strategies.

5. Real-World Application: Clinical Simulation in a Nursing Program

5.1 Background

In a nursing program at a mid-sized university, a clinical simulation is conducted as part of the curriculum for a third-year course on emergency care. The simulation involves a realistic scenario where students manage a patient experiencing acute respiratory distress in a mock emergency room. The exercise tests their ability to assess the patient, prioritize interventions, and make ethical decisions under time pressure. Five students

(H={S1,S2,S3,S4,S5}) participate, and their performance is evaluated by three stakeholders: a faculty instructor, a peer observer (another student), and a standardized patient (an actor trained to provide feedback).
Two key attributes are assessed:

1. A1 **C**linical Reasoning: The ability to accurately assess the patient's condition and choose appropriate interventions e.g., administering oxygen, calling for a consult.
2. A2 Ethical Decision-Making : The ability to balance patient autonomy, beneficence, and limited resources e.g., deciding whether to prioritize the patient over others in a busy ER.

Each stakeholder rates the students' performance as "excellent," "satisfactory," or "needs improvement." However, their perspectives often differ. For example, the instructor focuses on technical accuracy, the peer may be influenced by personal rapport, and the standardized patient emphasizes communication and empathy. These differences create uncertainty and conflicting evaluations, which the neutrosophic framework is designed to handle.

6.2 Applying the Neutrosophic Framework

The framework uses neutrosophic evaluation vectors to capture truth (positive agreement), falsehood (negative disagreement), and indeterminacy (uncertainty or conflicting views). The Extended Upside-Down Operator adjusts these evaluations based on narrative influences, such as biases or cultural expectations, and the Narrative Factor quantifies the strength of these influences. Below, we apply the model step-by-step, with full calculations for all students and attributes.

Step 1: Define the Sets
Students: H={S1,S2,S3,S4,S5}
Attributes: A={A1=clinical reasoning,A2=ethical decision-making}
Performance Levels: Vi={excellent,satisfactory,needs improvement}

Step 2: Assign Initial Neutrosophic Evaluations
For each student Sj and attribute A_i , a neutrosophic vector $N_i(S_j)=(T_{ij},I_{ij},F_{ij})$ created based on the stakeholders' ratings:
Tij: The proportion of "excellent" or "satisfactory" ratings, reflecting positive agreement.
Fij: The proportion of "needs improvement" ratings, reflecting disagreement.
Iij : The level of uncertainty, calculated as the proportion of conflicting or missing ratings.

The initial evaluations are based on the following stakeholder feedback:

1. **S_1**: The instructor rates clinical reasoning as "excellent" (technical accuracy is strong), the peer rates it "satisfactory" (less impressed by speed), and the patient rates it

"excellent." For ethical decision-making, all three rate "satisfactory" but note some hesitation in prioritizing the patient.

2. **S_2**: Ratings for clinical reasoning are mixed: the instructor gives "satisfactory" (protocol followed but slow), the peer gives "needs improvement" (perceived as hesitant), and the patient gives "excellent" (felt reassured). Ethical decision-making is similarly conflicted, with "satisfactory," "needs improvement," and "satisfactory."
3. **S3**: Clinical reasoning gets "satisfactory" from the instructor and peer, "excellent" from the patient. Ethical decision-making is rated "excellent" by the instructor and patient, "satisfactory" by the peer.
4. **S_4** : Clinical reasoning is "excellent" (instructor), "satisfactory" (peer), and "satisfactory" (patient). Ethical decision-making is "satisfactory" across all stakeholders.
5. **S_5**: Clinical reasoning is rated "needs improvement" (instructor, due to errors), "satisfactory" (peer), and "satisfactory" (patient). Ethical decision-making is "satisfactory" (instructor, peer) and "needs improvement" (patient, due to lack of empathy).

Using these ratings, the neutrosophic vectors are calculated (e.g., for T_{ij}, count "excellent" or "satisfactory" ratings divided by 3; for I_{ij}, estimate conflict based on rating divergence):

Student	$N_1(S_j)=(T_{1j},I_{1j},F_{1j})$	$N_2(S_j)=(T_{2j},I_{2j},F_{2j})$
S_1	(0.8, 0.1, 0.1)	(0.7, 0.2, 0.1)
S_2	(0.5, 0.4, 0.1)	(0.4, 0.5, 0.1)
S_3	(0.6, 0.3, 0.1)	(0.7, 0.2, 0.1)
S_4	(0.7, 0.2, 0.1)	(0.6, 0.3, 0.1)
S_5	(0.4, 0.5, 0.1)	(0.5, 0.4, 0.1)

Explanation

1. For S_1, A_1 : Two "excellent" and one "satisfactory" yield $T_{1,1} = 0.8$, low conflict gives $I_{1,1} = 0.1$, and no "needs improvement" gives $F_{1,1} = 0.1$.
2. For S_2, A_2 : One "satisfactory," one "needs improvement," and one "satisfactory" result in $T_{2,2} = 0.4$, high conflict gives $I_{2,2} = 0.5$, and one "needs improvement" gives $F_{2,2} = 0.1$.

Step 3: Assign Narrative Factors

Narrative factors $S_{ij} \in [0,1]$ reflect biases or contextual influences affecting evaluations:

1. Instructor Bias: The instructor prioritizes adherence to protocol, potentially undervaluing empathy or creative solutions.
2. Peer Bias: Personal relationships or competition may skew ratings (e.g., S_2 's peer may be overly critical due to rivalry).
3. Patient Bias: The standardized patient, from a cultural background valuing empathy, may penalize students who focus on technical tasks.

Based on observed influences (e.g., instructor's comments, peer dynamics, patient feedback), the narrative factors are:

Student	S_{1j} (Clinical Reasoning)	S_{2j} (Ethical Decision-Making)
S_1	0.05	0.10
S_2	0.30	0.25
S_3	0.15	0.20
S_4	0.10	0.15
S_5	0.20	0.30

Explanation

1. S_1, A_1 : Low narrative influence ($S_{1,1} = 0.05$) as ratings align with observed performance (strong technical skills).
2. S_2, A_1 : High narrative influence ($S_{1,2} = 0.30$) due to the instructor's strict protocol focus and peer rivalry, which may exaggerate perceived weaknesses.
3. S_5, A_2 : High narrative influence ($S_{2,5} = 0.30$) as the patient's cultural emphasis on empathy leads to a harsher rating.

Step 4: Apply the Extended Upside-Down Operator

The Extended Upside-Down Operator adjusts the neutrosophic vectors based on narrative factors:

$U_S\left(N_i\left(S_j\right); S_{ij}\right) = \left(\min\left(1, F_{ij} + S_{ij}\right), I_{ij}, \max\left(0, T_{ij} - S_{ij}\right)\right)$

This operator increases falsehood $\left(F_{ij}\right)$ and decreases truth $\left(T_{ij}\right)$ by the narrative factor, reflecting how biases distort perceptions, while indeterminacy (I_{ij}) remains unchanged.

Calculations:

Student S_1 :

A_1: $(0.8,0.1,0.1), S_{1,1} = 0.05 F_{1,1}^* = \min(1,0.1 + 0.05) = 0.15 I_{1,1}^* = 0.1 T_{1,1}^* = \max(0,0.8 - 0.05) = 0.75 N_1^*(S_1) = (0.15,0.1,0.75)$

A_2: $(0.7,0.2,0.1), S_{2,1} = 0.10 F_{2,1}^* = \min(1,0.1 + 0.10) = 0.20 I_{2,1}^* = 0.2 T_{2,1}^* = \max(0,0.7 - 0.10) = 0.60 N_2^*(S_1) = (0.20,0.2,0.60)$

Student S_2 :

A_1: $(0.5,0.4,0.1), S_{1,2} = 0.30 F_{1,2}^* = \min(1,0.1 + 0.30) = 0.40 I_{1,2}^* = 0.4 T_{1,2}^* = \max(0,0.5 - 0.30) = 0.20 N_1^*(S_2) = (0.40,0.4,0.20)$

A_2: $(0.4,0.5,0.1), S_{2,2} = 0.25 F_{2,2}^* = \min(1,0.1 + 0.25) = 0.35 I_{2,2}^* = 0.5 T_{2,2}^* = \max(0,0.4 - 0.25) = 0.15 N_2^*(S_2) = (0.35,0.5,0.15)$

Student S_3 :

A_1: $(0.6,0.3,0.1), S_{1,3} = 0.15 F_{1,3}^* = \min(1,0.1 + 0.15) = 0.25 I_{1,3}^* = 0.3 T_{1,3}^* = \max(0,0.6 - 0.15) = 0.45 N_1^*(S_3) = (0.25,0.3,0.45)$

A_2: $(0.7,0.2,0.1), S_{2,3} = 0.20 F_{2,3}^* = \min(1,0.1 + 0.20) = 0.30 I_{2,3}^* = 0.2 T_{2,3}^* = \max(0,0.7 - 0.20) = 0.50 N_2^*(S_3) = (0.30,0.2,0.50)$

Student S_4 :

A_1: $(0.7,0.2,0.1), S_{1,4} = 0.10 F_{1,4}^* = \min(1,0.1 + 0.10) = 0.20 I_{1,4}^* = 0.2 T_{1,4}^* = \max(0,0.7 - 0.10) = 0.60 N_1^*(S_4) = (0.20,0.2,0.60)$
A_2: $(0.6,0.3,0.1), S_{2,4} = 0.15 F_{2,4}^* = \min(1,0.1 + 0.15) = 0.25 I_{2,4}^* = 0.3 T_{2,4}^* = \max(0,0.6 - 0.15) = 0.45 N_2^*(S_4) = (0.25,0.3,0.45)$

Student S_5 :

A_1: $(0.4,0.5,0.1), S_{1,5} = 0.20 F_{1,5}^* = \min(1,0.1 + 0.20) = 0.30 I_{1,5}^* = 0.5 T_{1,5}^* = \max(0,0.4 - 0.20) = 0.20 N_1^*(S_5) = (0.30,0.5,0.20)$
A_2: $(0.5,0.4,0.1), S_{2,5} = 0.30 F_{2,5}^* = \min(1,0.1 + 0.30) = 0.40 I_{2,5}^* = 0.4 T_{2,5}^* = \max(0,0.5 - 0.30) = 0.20 N_2^*(S_5) = (0.40,0.4,0.20)$

Step 5: Calculate Narrative Distortion

The narrative distortion index is $D_{ij} = 2S_{ij}$, showing how much biases affect the evaluation:

Student	D_{1j}	D_{2j}
S_1	$2 \times 0.05 = 0.10$	$2 \times 0.10 = 0.20$
S_2	$2 \times 0.30 = 0.60$	$2 \times 0.25 = 0.50$
S_3	$2 \times 0.15 = 0.30$	$2 \times 0.20 = 0.40$
S_4	$2 \times 0.10 = 0.20$	$2 \times 0.15 = 0.30$
S_5	$2 \times 0.20 = 0.40$	$2 \times 0.30 = 0.60$

Step 6: Analyze Indeterminacy

Indeterminacy $\left(I_{ij}^*\right)$ remains the same as in the initial vectors, as the Upside-Down Operator does not affect it:

Student	I_{1j}^*	I_{2j}^*
S_1	0.1	0.2
S_2	0.4	0.5
S_3	0.3	0.2
S_4	0.2	0.3
S_5	0.5	0.4

Observations

1. S_2 has the highest indeterminacy ($I_{1,2}^* = 0.4, I_{2,2}^* = 0.5$), indicating significant disagreement among stakeholders. This could be due to the mixed ratings (e.g., "excellent" vs. "needs improvement" for clinical reasoning).
2. S_5 also shows high indeterminacy ($I_{1,5}^* = 0.5, I_{2,5}^* = 0.4$), suggesting unclear or conflicting feedback.
3. S_1 has the lowest indeterminacy $\left(I_{1,1}^* = 0.1\right)$, reflecting strong agreement on clinical reasoning.

Step 7: Calculate Truth-Falsehood Shifts

The shifts in truth and falsehood due to narrative influences are:

$$\Delta T_{ij} = T_{ij} - T_{ij}^* = S_{ij}$$
$$\Delta F_{ij} = F_{ij}^* - F_{ij} = S_{ij}$$

For $S_2, A_1: \Delta T_{1,2} = 0.5 - 0.2 = 0.30, \Delta F_{1,2} = 0.4 - 0.1 = 0.30$.

For $S_5, A_2: \Delta T_{2,5} = 0.5 - 0.2 = 0.30, \Delta F_{2,5} = 0.4 - 0.1 = 0.30$.

For $S_1, A_1: \Delta T_{1,1} = 0.8 - 0.75 = 0.05, \Delta F_{1,1} = 0.15 - 0.1 = 0.05$.

These shifts show how narrative factors reduce confidence in positive performance (truth) and increase perceptions of weakness (falsehood).

6.3 Results and Insights

The adjusted neutrosophic profiles $\left(E^*\left(S_j\right) = \left\{N_1^*\left(S_j\right), N_2^*\left(S_j\right)\right\}\right)$ for all students form the classlevel evaluation:

$$\varepsilon^*(H) = \{E^*(S_1), E^*(S_2), E^*(S_3), E^*(S_4), E^*(S_5)\}$$

High Indeterminacy for S_2 and S_5 :

S_2 : High indeterminacy ($I_{1,2}^* = 0.4, I_{2,2}^* = 0.5$) suggests stakeholders disagree

significantly, possibly due to differing expectations (e.g., instructor's focus on speed vs. patient's focus on reassurance).
S_5 : High indeterminacy ($I_{1,5}^* = 0.5$) in clinical reasoning indicates unclear feedback, likely due to errors noted by the instructor but not by others.

Action: Faculty should review these students' performances with stakeholders to clarify expectations and reduce ambiguity. For example, a debriefing session could align views on what constitutes "excellent" clinical reasoning.

High Narrative Distortion for S_2 and S_5 :

$S_2: D_{1,2} = 0.60, D_{2,2} = 0.50$ indicate strong biases, such as the instructor's protocol focus or peer rivalry, which lower perceived performance ($T_{1,2}^* = 0.20$).

$S_5: D_{2,5} = 0.60$ reflects the patient's cultural bias toward empathy, increasing perceived falsehood ($F_{2,5}^* = 0.40$) .

Action: Introduce training for evaluators to recognize and mitigate biases. For instance, the instructor could use a rubric that balances technical and interpersonal skills.

Stable Performance for S_1 :

Low indeterminacy ($I_{1,1}^* = 0.1$) and narrative distortion ($D_{1,1} = 0.10$) suggest S_1 's strong clinical reasoning is consistently recognized.

Action: Use S_1 's performance as a benchmark for training others, highlighting effective practices.

Program-Wide Trends:

Average indeterminacy: avg $I_{1j}^{*} = (0.1 + 0.4 + 0.3 + 0.2 + 0.5)/5 = 0.30$ for clinical reasoning; avg $I_{2j}^{*} = (0.2 + 0.5 + 0.2 + 0.3 + 0.4)/5 = 0.32$ for ethical decisionmaking.

6.4 Implications for Nursing Education

This application shows how the neutrosophic framework can improve evaluation in nursing education:

1. High indeterminacy for S_2 and S_5 highlights areas where feedback is inconsistent. Faculty can develop detailed rubrics to ensure stakeholders evaluate attributes like ethical decision-making consistently.
2. High narrative distortion for S2 suggests biases unfairly lower performance perceptions. Training evaluators to balance technical and interpersonal skills can create fairer assessments.
3. The model identifies students needing extra support. For S5 , targeted coaching on clinical reasoning could address the instructor's concerns about errors.
4. The higher indeterminacy in ethical decision-making indicates a curriculum gap. Adding case studies on ethical dilemmas could improve student skills and evaluator agreement.

Unlike traditional evaluation methods (e.g., numerical grades), which force a single score and ignore conflicting views, this framework captures the complexity of real-world assessments. It shows not only how well students perform but also how biases and disagreements affect evaluations. The calculations are clear and repeatable, making the model practical for educators. For example, the university can use this approach in future simulations to track improvements in evaluation consistency or bias reduction.

This application draws on Smarandache's Upside-Down Logics [4], showing how biases can "falsify" strong performance e.g., S2's clinical reasoning appears weaker due to instructor bias or "truthify" weaker performance. The Narrative Factor quantifies these effects, making it easier to address them. The model can be extended to other courses, attributes e.g., communication, or settings e.g., clinical placements, offering a flexible tool for nursing education.

6. Conclusion

This study developed a novel mathematical model to enhance the evaluation of nursing education quality, addressing the limitations of traditional assessment methods. By integrating Neutrosophic Logic, the model captures the complexity of subjective evaluations, allowing for truth, falsehood, and uncertainty to coexist. The incorporation of Upside-Down Logics provides a systematic way to understand how contextual factors can invert perceptions of performance, such as when a student's strong clinical skills are undervalued due to bias. The Narrative Factor further enriches the model by measuring the influence of personal stories and cultural perspectives, offering a quantitative approach to a typically qualitative challenge.

The practical application of the model demonstrates its value in real-world settings, revealing areas of high uncertainty and bias that educators can target for improvement. For example, it can guide faculty in refining evaluation criteria or training evaluators to reduce subjective distortions. Unlike conventional methods that oversimplify complex assessments, this framework provides a comprehensive and adaptable tool for nursing education. Looking forward, the model can be applied to larger datasets, additional attributes like communication skills, or other fields such as medical or teacher training. This work lays the foundation for fairer, more nuanced evaluation systems, ultimately supporting better educational outcomes.

References

1. Benner, P., Tanner, C., & Chesla, C. (2009). *Expertise in nursing practice: Caring, clinical judgment, and ethics* (2nd ed.). Springer Publishing Company.
2. Smarandache, F. (2002). Neutrosophy, a new branch of philosophy. *Multiple Valued Logic: An International Journal, 8*(3), 297–384.
3. Smarandache, F. (2002). A unifying field in logics: Neutrosophic logic. *Multiple Valued Logic: An International Journal, 8*(3), 385–438.
4. Smarandache, F. (2024). Upside-Down logics: Falsification of the truth and truthification of the false. *Systems Assessment and Engineering Management, 1*, 1–7. https://doi.org/10.61356/jsaem.2024.1248
5. Rivieccio, U. (2012). Neutrosophic logics: Prospects and problems. *Fuzzy Sets and Systems, 205*, 30–46. https://doi.org/10.1016/j.fss.2012.03.011
6. Wang, H., Smarandache, F., Zhang, Y., & Sunderraman, R. (2010). Single valued neutrosophic sets. *Multispace & Multistructure. Neutrosophic Transdisciplinarity (100 Collected Papers of Sciences), 4*, 410–413.
7. Smarandache, F. (1997). *Collected papers, Vol. II*. University of Kishinev Press.
8. Burgin, M. (2024). Diophantine and non-Diophantine arithmetic operations with numbers in science and everyday life. Retrieved April 24, 2024, from http://brnetics%20are%20Archmedean

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