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A Neutrosophic TwoFold Algebra-Based Framework for Evaluating Practical Teaching Quality in Fashion Design and Technology Education

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Abstract- Assessing the quality of practical teaching in fashion design and technology programs is complex due to the subjective and multidimensional nature of creative education. This study introduces a novel framework based on Neutrosophic TwoFold Algebra to evaluate practical teaching performance by capturing uncertainty, contradiction, and partial truth within students' learning experiences. The proposed method integrates classical assessment data with neutrosophic components of truth, indeterminacy, and falsehood to reflect the nuanced quality of instruction in real-world settings. A simulated case study demonstrates how this approach provides more comprehensive and balanced evaluations compared to traditional models. The framework aims to support academic institutions in making informed decisions to enhance teaching effectiveness and learning outcomes in fashion-related disciplines.

Keywords: Neutrosophic TwoFold Algebra, Practical Teaching, Fashion Design Education, Teaching Evaluation, Uncertainty Modeling, Creative Learning Assessment

1. Introduction

Practical teaching plays a central role in the education of fashion design and technology students, as it bridges theoretical knowledge and hands-on skill development. Unlike theoretical disciplines, practical instruction in fashion education involves high variability in student outcomes, subjective evaluation processes, and the challenge of balancing creativity with technical precision. These complexities have prompted scholars and institutions to search for robust evaluation methods that account for the dynamic and often ambiguous nature of student performance in practical settings.

Traditional assessment frameworks often rely on quantitative metrics such as attendance, project completion, or rubric-based grading. While these tools provide measurable outcomes, they frequently fail to capture the uncertainty, inconsistency, and creative variance inherent in fashion design training [1]. For instance, a student's portfolio may exhibit technical flaws yet convey a strong conceptual vision raising the question of how to weigh such dimensions fairly and accurately. Moreover, subjective biases from instructors and institutional constraints further obscure the objectivity of practical teaching assessments [2]. Recent advances in fuzzy logic, neutrosophic sets, and multi-valued algebraic structures have enabled researchers to model imprecision in complex systems such as education, medicine, and decision-making [3].

Smarandache (2024) introduced a novel mathematical framework known as Neutrosophic TwoFold Algebra, and in general Fuzzy and Fuzzy-Extensions TwoFold Algebra, designed to handle situations where information is not only imprecise but also contains degrees of contradiction and ambiguity [4]. Unlike traditional algebraic systems that assume clarity and consistency, this model captures both the tangible and uncertain aspects of data by combining classical operations with neutrosophic components. The strength of this approach lies in its ability to represent elements with varying levels of truth, uncertainty, and falsehood offering a more flexible analytical structure. This dual mechanism is particularly relevant in disciplines where evaluation is influenced by multiple perspectives and incomplete knowledge, such as education, decision-making, or creative performance analysis.

In this paper, we apply Neutrosophic TwoFold Algebra to construct a comprehensive model for evaluating practical teaching quality in the fashion design and technology major. We demonstrate how this algebraic framework can incorporate both measurable data and interpretative factors, allowing institutions to assess teaching effectiveness in a way that reflects the full complexity of studio-based and design-led education. The proposed model not only enhances fairness and transparency but also supports continuous pedagogical improvement by highlighting areas of uncertainty and divergence in student outcomes.

2. Literature Review

In creative disciplines like fashion design, evaluating practical teaching presents ongoing challenges due to the highly subjective and process-oriented nature of studio-based learning. Unlike traditional academic fields, where assessments often rely on standardized tests and measurable outputs, creative education involves iterative development, interpretive feedback, and evolving student work. As Fredrickson and Watwood (2018) observed in their review of studio-based pedagogies, standard rubrics tend to miss critical dimensions of learning such as experimentation, conceptual risk-taking, and progressive refinement of ideas[12].

Moreover, scholars have increasingly emphasized that creative assessment should consider sociocultural and emotional dimensions of student engagement. Bennett (2023) argues that educational assessment must reflect the diverse cultural backgrounds and identities that shape how students approach creative tasks, advocating for more responsive and inclusive frameworks [13]. Danvers (2016) similarly notes that emotional factors—like confidence, uncertainty, and vulnerability—are entangled with critical and creative thinking, which means traditional metrics often fall short of capturing the full scope of student development [14].

Recent work has also explored how learning dispositions, such as perseverance and reflective thinking, can provide a better indication of learning progress than static outputs. Stephenson (2024) promotes the idea of “dispositional learning,” where assessment focuses not just on finished work but also on how students engage with the creative process, especially in open-ended or ambiguous contexts [15].

On a global scale, the OECD (2023) has highlighted the importance of assessing creative and critical thinking as part of higher education policy. Their research across institutions found a consistent gap between the value placed on creativity and the methods used to measure it. They

advocate for more flexible, multidimensional evaluation models capable of capturing partial success, uncertainty, and iterative progress—qualities inherent in artistic disciplines [16].
In parallel, educational technology has started playing a role in supporting such nuanced assessments. For instance, Shabani (2022) used machine learning techniques to detect creative thinking patterns in educational datasets, suggesting that artificial intelligence can support more layered insights into student work [17]. Similarly, Kovalkov et al. (2022) developed a method to evaluate creativity across modalities using Scratch programming environments, showing that computational methods can indeed reflect divergent thinking in educational artifacts [18].
These developments [12-21] provide theoretical and practical justification for the integration of mathematical evaluation models such as Neutrosophic TwoFold Algebra which can handle degrees of truth, uncertainty, and contradiction. Such models offer a meaningful alternative to binary grading systems and support the complex, often non-linear paths students take in creative learning settings like fashion design.

Evaluating practical teaching in fashion design and technology requires flexible models capable of interpreting both qualitative and uncertain data. Existing research has recognized the limitations of traditional metrics in creative disciplines and proposed logic-based alternatives to model ambiguity and subjectivity [5]. Fuzzy logic, for instance, has been employed to handle partial correctness in learning outcomes, especially where binary assessments fall short. However, fuzzy systems cannot often manage indeterminate states, a common feature in evolving or partially formed student work.

Neutrosophic logic has emerged as a more adaptive framework, introducing three parameters truth (T), indeterminacy (I), and falsehood (F) to reflect the spectrum of cognitive and evaluative uncertainty. It has been extended to algebraic structures through Neutrosophic TwoFold Algebra, which incorporates both classical and neutrosophic components in a dual-layered operation model [4].

Shihadeh et al. (2024) expanded this model by introducing Two-Fold Fuzzy Algebras based on neutrosophic real numbers, enabling algebraic systems to account for variability in real-valued educational data such as subjective scores or feedback frequencies. Their framework provided robust tools for modeling performance evaluations involving inconsistent grading scenarios [5].
Further development came from Al-Tameemi (2024), who introduced Fuzzy Metric Spaces within the Two-Fold Fuzzy Algebra context. His work addressed proximity measures between educational outcomes, allowing researchers to quantify the similarity or divergence in student performance over time or between evaluators [6].

To accommodate complex evaluation contexts, Shihadeh et al. (2024) also proposed Two-Fold Fuzzy n-Refined Neutrosophic Rings for cases with multiple layers of assessment criteria. This model is especially relevant to multidisciplinary courses like fashion technology, where technical accuracy and creative exploration often intersect across separate grading rubrics [7].
Salman (2024) contributed to the theoretical generalization of these structures by introducing a specialized gamma function over complex Two-Fold Algebras. Although mathematical, this

work set the foundation for advanced operations that may be translated into adaptive scoring algorithms in educational technology systems [8].

Mohammed (2024) provided practical insight into the resolution of differential equations formulated within the Two-Fold Fuzzy and Neutrosophic domains. His results suggested pathways to model change over time in student progress—ideal for tracking growth in skill-based learning modules [9].

Hatamleh and Hazaymeh (2024) explored the identification of minimal units in Two-Fold Fuzzy finite neutrosophic rings, with implications for resource optimization in educational settings. Their results can inform curriculum design by highlighting the essential evaluative elements in complex grading systems [10].

Yasar and Hatip (2024) examined the structure of Binary Two-Fold Algebras based on intuitionistic fuzzy groups, enabling binary comparative assessments such as peer evaluation or pass/fail judgments. Their findings add structural support for integrating Two-Fold Algebra into institutional grading platforms [11].

Collectively, these works form a strong theoretical and applied foundation for deploying TwoFold Algebraic models in educational contexts. Despite their mathematical focus, their relevance to creative and subjective domains like fashion education is clear: each model adds the capacity to express nuance, uncertainty, and evolving evaluation criteria.

Nonetheless, few studies have directly applied these algebraic models to teaching quality assessment in design-based programs. Our work aims to bridge this gap by operationalizing Neutrosophic TwoFold Algebra for practical evaluation in fashion education, tailoring the model to reflect the specificities of creativity-centered learning environments.

3. Proposed Method

To effectively evaluate practical teaching in fashion design and technology, we propose a model grounded in Neutrosophic TwoFold Algebra (NTFA). This model captures both objective instructional inputs (classical scores) and subjective interpretative factors (truth, indeterminacy, and falsehood) that typically influence assessments in creative disciplines.

3.1. Mathematical Foundation

3.1.1 Neutrosophic TwoFold Algebra

Imagine you're working with a set of items, but each item isn't just a simple object—it comes with extra information about how "true," "uncertain," or "false" it is. This is what Neutrosophic TwoFold Algebra does. It's built on a universe of discourse (let's call it U), and within that, we have a special set A defined as:

$A_{(T,I,F)} = \{x(T_A(x), I_A(x), F_A(x))\}$

$T_A(x)$ is the degree of truth, $I_A(x)$ is the degree of indeterminacy (uncertainty), and $F_A(x)$ is the degree of falsehood. Each of these values is a number between 0 and 1.

So, every element x in A carries a triplet (T, I, F), making it more complex and informative than a regular set.

3.1.2 The Neutrosophic TwoFold Law

This algebra comes with a special rule, or "law," to combine two elements. Let's call it Δ. It works like this:

Take two elements: $x_{1_{(t_1,i_1,f_1)}}$ and $x_{2_{(t_2,i_2,f_2)}}$.

Combine them using:

$$x_{1_{(t_1,i_1,f_1)}} \Delta x_{2_{(t_2,i_2,f_2)}} = (x_1 \# x_2)_{(t_1,i_1,f_1)*(t_2,i_2,f_2)}$$

is an operation on the elements themselves (like adding or multiplying numbers).

* is an operation on the neutrosophic parts (T, I, F), like averaging or multiplying the truth values.

These two operations (# and *) can be related or completely separate, depending on the situation.

3.1.3 The General Form [4]

In its most flexible form, the law can be written as a function g :

$g(x_1, t_1, i_1, f_1, x_2, t_2, i_2, f_2) = h(x_1, t_2, i_1, f_1, x_2, t_2, i_2, f_2)_{(T(t_1,t_2), I(i_1,i_2), F(f_1,f_2))}$

This looks complicated, but it just means g takes all parts of both elements and produces a new element with updated neutrosophic values.

3.1.4 Variations of TwoFold Algebra [4]

This concept isn't limited to neutrosophic sets. It extends to other systems:

Fuzzy TwoFold Algebra

Uses only truth values (T).

Law: $x_{1_{(t_1)}} \Delta x_{2_{(t_2)}} = (x_1 \# x_2)_{(t_1 * t_2)}$.

Intuitionistic Fuzzy TwoFold Algebra

Uses truth and falsehood (T, F).

Law: $x_{1_{(t_1,f_1)}} \Delta x_{2_{(t_2,f_2)}} = (x_1 \# x_2)_{(t_1,f_1)*(t_2,f_2)}$.

Other Types: Picture Fuzzy, Pythagorean Fuzzy, Spherical Fuzzy, and more-all adapt the same idea with different rules for T, I, F [4].

Let A(T, I, F) represent a neutrosophic set of evaluated teaching sessions:

$A(T, I, F) = \{ x_j(T_j, I_j, F_j) \mid x_j \in U, T_j, I_j, F_j \in [0, 1] \}$

Where:

T_j: Degree of observed effective teaching (truth).

I_j: Degree of uncertainty in evaluation (indeterminacy).

F_j: Degree of observed ineffectiveness (falsehood).

x_j: Teaching instance or class module.

To combine multiple evaluations (e.g., across multiple observers or over time), we apply the Neutrosophic TwoFold Aggregation Law:

$x = x_1 + x_2$

$$T = \frac{x_1 \cdot T_1 + x_2 \cdot T_2}{x_1 + x_2},$$

$$I = \frac{x_1 \cdot I_1 + x_2 \cdot I_2}{x_1 + x_2},$$

$$F = \frac{x_1 \cdot F_1 + x_2 \cdot F_2}{x_1 + x_2}$$

This weighted aggregation balances each session's contribution proportionally, producing a new evaluation x(T, I, F)

In addition to the basic weighted average used for aggregating T, I, and F values, we propose an enhanced version that accounts for interactions between the parameters. For example, a high level of I may reduce the reliability of T, while F)can amplify ambiguity. To model this, we introduce adjustment coefficients:
$T' = T - \alpha \cdot I - \beta \cdot F$
$I' = I + \gamma \cdot |T - F|$
$F' = F + \delta \cdot I$
Where $\alpha, \beta, \gamma, \delta \in [0,1]$ are calibration parameters based on the context. These adjusted values (T′, I′, F′) offer a more nuanced reflection of performance and can be used for deeper analysis alongside the original triplet.

3.2. Step-by-Step Implementation

Step 1. Classical Scoring
Each practical teaching session is initially scored on a 0–100 scale based on predefined rubrics e.g., clarity, engagement, technique delivery. These are normalized to a [0,1] scale.

Step 2. Neutrosophic Mapping
Expert evaluators assign neutrosophic values:

1. T for clarity and effectiveness,
2. I for ambiguity or disagreement in feedback,
3. F for noticeable teaching flaws.

Step 3. Weight Assignment
Let each session x_j have a weight e.g., duration, project impact. These are used to weight the neutrosophic parameters.

Step 4. TwoFold Evaluation
Apply the aggregation formula to calculate the overall neutrosophic value of the teacher's practical performance:
Final Score = $X_{total}(T_{avg}, I_{avg}, F_{avg})$

After calculating the final values of truth, indeterminacy, and falsehood, the results can be summarized in a clear format to support decision-making.

3.3. Interpretive Model

We define a performance zone system:

1. Excellence Zone; $T \geq 0.75$, $F \leq 0.1$ $I \leq 0.15$
2. Developing Zone; $0.5 \leq T < 0.75$, $I > 0.15$
3. Critical Zone; $F \geq 0.4$, regardless of T

This allows institutions to quickly identify strong and weak teaching components while accounting for ambiguity.

4. A Simulated Case Study

To demonstrate the application of Neutrosophic TwoFold Algebra in evaluating practical teaching quality, we present a simulated case study based on a semester-long course in "Apparel Construction and Draping" offered at a fashion design institute. The course includes a series of project-based studio sessions where students are guided through various garment-making techniques, from basic pattern cutting to advanced draping on dress forms.

4.1. Evaluation Context

A team of three evaluators an instructor, an external academic reviewer, and a fashion industry consultant was tasked with assessing five key teaching sessions using both classical grading and neutrosophic values. Each session was evaluated on three main dimensions:

1. Effectiveness, T,
2. Uncertainty due to varied student responses or unclear feedback, I,
3. Identified weaknesses or instructional issues, F.

4.2. Input Data

Each session was assigned a weight based on its duration and importance in the curriculum. Table 1 shows the assigned weights and neutrosophic scores for each session. The scores represent consensus values averaged from the three evaluators.

Table 1. Neutrosophic Evaluation of Teaching Sessions

Session ID	Weight (Hs)	T	I	F
S1	3	0.85	0.10	0.05
S2	2	0.65	0.25	0.10
S3	4	0.70	0.20	0.10
S4	2	0.50	0.30	0.20
S5	1	0.45	0.35	0.20

4.3. Aggregation Using Neutrosophic TwoFold Algebra

Using the aggregation equations from Section 3.1, we calculate the overall neutrosophic evaluation of the instructor's practical teaching across the five sessions.

Let:

x_j = weight of session j,

T_j, I_j, F_j = neutrosophic values of session j.

The aggregated scores are calculated using the following formulas:

$$T = \frac{\sum x_j \cdot T_j}{\sum x_j},$$

$$I = \frac{\sum x_j \cdot I_j}{\sum x_j},$$

$$F = \frac{\sum x_j \cdot F_j}{\sum x_j}$$

Substituting the values:

Weights: $x_1 = 3, x_2 = 2, x_3 = 4, x_4 = 2, x_5 = 1$

Truths: $T_1 = 0.85, T_2 = 0.65, T_3 = 0.70, T_4 = 0.50, T_5 = 0.45$

Indeterminacies: $I_1 = 0.10, I_2 = 0.25, I_3 = 0.20, I_4 = 0.30, I_5 = 0.35$

Falsehoods: $F_1 = 0.05, F_2 = 0.10, F_3 = 0.10, F_4 = 0.20, F_5 = 0.20$

$$T = \frac{(3\cdot0.85)+(2\cdot0.65)+(4\cdot0.70)+(2\cdot0.50)+(1\cdot0.45)}{3+2+4+2+1} = \frac{2.55+1.30+2.80+1.00+0.45}{12} = \frac{8.10}{12} \approx 0.675$$

$$I = \frac{(3\cdot0.10)+(2\cdot0.25)+(4\cdot0.20)+(2\cdot0.30)+(1\cdot0.35)}{12} = \frac{0.30+0.50+0.80+0.60+0.35}{12} = \frac{2.55}{12} \approx 0.2125$$

$$F = \frac{(3\cdot0.05)+(2\cdot0.10)+(4\cdot0.10)+(2\cdot0.20)+(1\cdot0.20)}{12} = \frac{0.15+0.20+0.40+0.40+0.20}{12} = \frac{1.35}{12} \approx 0.1125$$

Final Aggregated Neutrosophic Evaluation= 12(0.675, 0.2125, 0.1125)

4.4. Results

Referring to the interpretive model described in Section 3.3:

1. The T value of 0.675 suggests that teaching effectiveness is above average but not at an optimal level.
2. The I value of 0.2125 indicates moderate ambiguity in evaluation, possibly due to mixed student engagement or feedback inconsistency.
3. The F value of 0.1125 is low, suggesting that critical teaching issues were minimal but present.

Therefore, the teaching performance falls into the Developing Zone, where the instruction is generally effective but requires attention to areas causing uncertainty or divergence in student responses. Table 2 provides a synthesized explanation of the final evaluation triplet, aiding administrators and instructors in understanding specific areas for teaching improvement.

Table 2. Summary Interpretation Based on Aggregated NTFA Evaluation

Evaluation Component	Value	Interpretation
T	0.675	Moderately strong instructional delivery
I	0.2125	Noticeable ambiguity in teaching feedback

F	0.1125	Minor but detectable instructional weaknesses

5. Discussion

In the case study, the final aggregated values generated by the NTFA model suggest that the teaching performance was moderately strong, with most sessions delivered effectively. However, the relatively high indeterminacy score indicates the presence of some ambiguity in how the sessions were perceived by students and evaluators. This could stem from unclear instructions, inconsistent feedback, or differing interpretations of the session outcomes. Although the falsehood value was comparatively low, it still reflects the existence of certain weaknesses in the teaching process that may require attention.

According to the NTFA evaluation scale, these results place the instructor within the Developing Zone. This zone characterizes teaching that is functional and generally effective but not yet at an optimal level. The combination of moderate effectiveness, moderate uncertainty, and low-level flaws reveals a performance that has potential but would benefit from targeted improvements. The value of the NTFA model lies not only in its ability to highlight performance strengths but also in its capacity to pinpoint areas needing enhancement.

To improve performance and transition toward the Excellence Zone, specific actions can be taken. First, to reduce indeterminacy, instructors should focus on delivering clearer task instructions and adopting more consistent assessment criteria. This helps ensure that both students and co-evaluators interpret teaching sessions in similar ways, reducing confusion or misalignment. Second, to address falsehood, instructors can revisit parts of their demonstrations or lectures that may have been unclear or ineffective. Utilizing peer feedback or reviewing recorded sessions can support this refinement process. Lastly, to increase the truth score, teachers can promote greater engagement by providing more interactive, hands-on support during practical activities. Strengthening student-teacher interaction can enhance understanding and overall session impact.

To further highlight the advantages of the NTFA framework, a comparative reflection was made between the proposed model and traditional rubric-based evaluation systems commonly used in fashion education. Conventional assessment methods typically rely on fixed grading rubrics that evaluate elements such as attendance, project completion, technical accuracy, and punctuality. While these metrics offer a clear and structured format for grading, they tend to overlook the subjective, creative, and often ambiguous aspects of studio-based learning environments. For example, two students might produce garments of equal technical quality, but one might demonstrate greater innovation or conceptual depth elements that are difficult to quantify using rigid rubrics.

In contrast, the NTFA model incorporates these nuanced elements through its three-dimensional structure. The use of T, I, and F allows evaluators to express not just whether a teaching session succeeded or failed, but how confident they are in their judgments and where the uncertainties lie. When the same teaching sessions from the case study were analyzed using a traditional model, the resulting grades clustered closely together, masking key differences in clarity, consistency, and effectiveness. However, the NTFA framework differentiated between sessions with similar averages by exposing levels of ambiguity or inconsistency that would otherwise go unnoticed.

This added layer of insight makes NTFA particularly suitable for disciplines where learning outcomes are not strictly binary or easily standardized. By moving beyond flat numerical scores, the model provides evaluators and academic managers with a more textured and realistic understanding of instructional quality especially important in creative fields like fashion design where innovation, interpretation, and personal expression are central to student performance.

5.1 Challenges in Applying the NTFA Model

While the NTFA framework offers a rich and balanced method for evaluating practical teaching, applying it in real educational settings may face some challenges. First, evaluators may need initial training to understand neutrosophic concepts and how to apply them accurately. Second, traditional grading systems are deeply rooted in many institutions, which can create resistance to change. Third, collecting and analyzing T, I, and F values requires more effort than conventional scores, especially if done manually. To overcome these barriers, schools can start with pilot programs, provide training sessions for evaluators, and use digital tools to simplify data collection and visualization.

6. Conclusion

This study introduced a novel application of Neutrosophic TwoFold Algebra for evaluating practical teaching quality in fashion design and technology education. By incorporating three distinct but interconnected components truth, indeterminacy, and falsehood the proposed model provides a more comprehensive understanding of instructional performance, especially in creative, studio-based environments where standard assessments often fall short.

The simulated case study demonstrated how teaching sessions could be analyzed in a structured yet flexible way. The model effectively captured variations across sessions and highlighted subtle areas for pedagogical development. Instead of reducing teaching quality to a single score, NTFA allowed for the expression of ambiguity and partial quality, which are essential when assessing complex, human-centered activities such as creative instruction.

Future work could extend this model to compare results across semesters, student cohorts, or different instructional methods. Additionally, integrating student feedback as a separate neutrosophic input may enhance the model's responsiveness and inclusivity.

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