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A Neutrosophic–fsQCA Framework for Strategic School Management: Superset and Coincidence Analyses of Student Social Competence

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Abstract. This study proposes a neutrosophic–fsQCA framework to analyze strategic school management under conditions of uncertainty. Using data from 20 educators at the Colegio Bicentenario Louis Pasteur in Ecuador, neutrosophic Likert scales were applied to capture perceptions of interpersonal communication (IC), social interaction experiences (SIE), self-esteem and self-efficacy (SS), and their influence on students' social competence (ECS). The neutrosophic triplets (T, I, F) were transformed into fuzzy sets through a fuzzification process, enabling subsequent Qualitative Comparative Analysis. Two complementary procedures were conducted: a superset analysis to assess necessary and sufficient conditions, and a coincidence analysis to explore overlap among conditions. Results indicate that SS plays a pivotal role, emerging as a bridging factor with the highest overlap with both IC and ECS. Superset analysis revealed multiple equifinal pathways, with combinations such as SIE ∗ SS and IC ∗ SS showing high consistency and coverage. These findings highlight the importance of psychosocial factors and demonstrate that student social competence emerges from interacting conditions rather than isolated variables. Methodologically, the study contributes by integrating neutrosophic modeling with fsQCA, offering a replicable approach for handling uncertainty in educational and social research.

Keywords: Neutrosophic Sets, fsQCA, Coincidence Analysis, Strategic School Management, Social Competence, Uncertainty.

1. Introduction

Strategic school management faces significant challenges due to the inherent uncertainty of educational environments, such as changes in policies, resource constraints, and diverse expectations from stakeholders. These factors complicate the design of strategies that balance academic, administrative, and social objectives, especially in institutions like Colegio Bicentenario Louis Pasteur, where organizational complexity requires innovative decision-making tools. Traditional management models often rely on linear approaches that fail to adequately account for contradictions and ambiguities, resulting in rigid strategies poorly adapted to dynamic contexts. This problem underscores the need for a paradigm that incorporates analytical methods capable of modeling uncertainty in order to optimize decision-making.

Several studies have addressed school strategic management from conventional perspectives such as SWOT analysis or indicator-based planning. For example, a recent study examined the implementation of performance-based management models [1], yet neglected the role of uncertainty in

decision-making. Similarly, research on transformational leadership emphasized its positive effects on teacher motivation [2] but overlooked contradictions between institutional and external demands. Other work on resource allocation in public schools [3] highlighted the difficulty of prioritizing needs in dynamic contexts. These limitations reveal a gap in the literature: the lack of models that explicitly integrate uncertainty and contradictions into school management.

Neutrosophic set theory offers a promising solution to this problem. Unlike traditional approaches, it allows the simultaneous representation of truth, falsity, and indeterminacy, making it particularly suitable for educational settings where information is often incomplete or contradictory. Despite its potential, applications of neutrosophic sets in school management remain limited. Some studies addressing educational planning under uncertainty [4] have proposed probabilistic approaches, but without considering neutrosophic logic. This gap justifies the need to design a strategic paradigm that incorporates neutrosophic sets and can be operationalized through complementary analytical techniques such as fuzzification, superset analysis, and coincidence analysis, thus offering a more robust and comprehensive framework.

The relevance of this study lies in its potential to transform the way schools approach decision-making in complex environments. In contexts like that of the Louis Pasteur Bicentennial School, where student diversity and external demands create significant uncertainty, a neutrosophic-based paradigm provides flexibility, adaptability, and resilience. This not only facilitates more efficient resource allocation but also strengthens organizational cohesion and responsiveness to change. Furthermore, such an approach can be generalized to other educational institutions, particularly in Latin America, where schools face structural challenges such as limited budgets and frequent regulatory reforms [6].

Uncertainty in school management not only affects planning but also influences the institutional capacity to meet the expectations of teachers, students, and families. A study on satisfaction in educational contexts [5] noted that unclear objectives and contradictory policies can generate conflict, which traditional models fail to address. By explicitly modeling uncertainty, neutrosophic theory enables managers to evaluate multiple scenarios simultaneously and make decisions that are both more accurate and more context-sensitive.

The objective of this research is therefore to develop a strategic school management paradigm that integrates neutrosophic set theory to optimize decision-making in uncertain contexts, using the Colegio Bicentenario Louis Pasteur as a case study. Specifically, the study seeks to design a framework that enables school leaders to prioritize strategies, allocate resources, and resolve conflicts under conditions of indeterminacy. The central hypothesis proposes that the integration of neutrosophic set theory into school management will significantly improve the accuracy, adaptability, and empirical relevance of decisions compared to traditional models.

In conclusion, this work proposes an innovative approach to educational management, combining neutrosophic logic with fsQCA-based tools, including superset and coincidence analyses. By applying this paradigm to the Colegio Bicentenario Louis Pasteur, the study aims to provide both theoretical contributions and practical solutions, addressing a critical gap in the literature and offering a replicable model for schools in complex environments [7].

2. Preliminaries

2.1. Complexity Theory, Causality, and Neutrosophic Sets.

The relationships between variables are rarely manifested directly or predictably; more frequently, they take on complex configurations, characterized by non-linear dynamics, as complexity theory warns. From this perspective, the same condition can give rise to very different effects depending on the environment in which it occurs. This approach is based on three central notions: conjunction, equifinality, and causal asymmetry [8]. The conjunction principle states that outcomes emerge from the combined action of multiple factors that interact simultaneously, rather than from a single isolated variable. Equifinality maintains that the same outcome can be achieved through different trajectories

or initial conditions. Finally, causal asymmetry emphasizes that the existence of certain factors can lead to a result, but their absence does not guarantee that the phenomenon will be avoided [9].

To illustrate, consider a restaurant known for the quality of its cuisine. While this characteristic is a key attraction, it does not necessarily ensure a steady flow of customers, as factors such as an unfavorable location or lack of parking can discourage visits [10]. Conversely, a restaurant with average food could maintain a high level of clientele if it excels in aspects such as customer service, geographic accessibility, or the provision of complementary activities. This example demonstrates that the relationship between quality, location, customer service, and visitor numbers does not follow a fixed or universal pattern.

Thus, the principles derived from complexity theory highlight that the links between causes and effects in social phenomena lack stability, are changeable, and strongly depend on context. In this context, neutrosophy provides an additional level of understanding by recognizing that indeterminacy and uncertainty are inherent dimensions of all social dynamics. Neutrosophic set theory, thanks to its ability to integrate degrees of truth, falsity, and indeterminacy, presents itself as a more robust and precise analytical framework for examining these multiple and variable relationships as proposed in [11].

2.2. Neutrosophic Likert scales

Surveys using neutrosophic Likert scales [12] effectively measure the diversity of opinions and their influence on public policy and social discourse, capturing areas of consensus, disagreement, and ambivalence.

Below we present the fundamental definitions and concepts related to neutrosophic sets and single-valued neutrosophic sets .

Definition 1 ([13]). Let U be a universe of discourse. $N = \{(x , T (x), I (x), F (x)): x \in U \}$ is a neutrosophic set, denoted by a truth membership function, $TN : U \rightarrow]0 - , 1+[$; an indeterminate membership function , $IN : U \rightarrow]0 - , 1+[$; and a falsehood membership function , $FN : U \rightarrow]0 - , 1+[$.

Single-valued neutrosophic sets provide a way to represent and analyze possible elements in the universe of discourse U

Definition 2 ([14]). Let U be a discursive universe. A single-valued neutrosophic set is defined as $N = \{(x , T (x), I (x), F (x)): x \in U \}$, which is identified by a truth membership function, $TN : U \rightarrow [0, 1]$; indeterminacy membership function , $IN : U \rightarrow [0, 1]$; and falsehood membership function , $FN : U \rightarrow [0, 1]$, with $0 \leq TN (x)+ IN (x)+ FN (x) \leq 3$

Using neutrosophic scales with single-valued neutrosophic sets, responses are categorized according to the total of the True, Indeterminate, and False components as follows [15]:

- T+I+F<1: Incomplete
- T+I+F=1: Complete
- T+I+F>1: Contradictory

These values are obtained because, in many cases, opinions are incomplete or contradictory. This classification is one of the advantages of using neutrosophic methods, as it allows for a more nuanced understanding of the different degrees of truth, indeterminacy, and falsity in the responses.

3. Materials and Methods

The first step in the research process was to clearly define the desired outcome, namely the accurate identification and description of the phenomenon under study. Establishing this objective provided the conceptual framework and analytical approach that guided all subsequent phases of the investigation.

To capture the complexity of perceptions and responses, neutrosophic Likert scales were developed and applied. Unlike conventional Likert scales, which rely on a single numerical continuum (e.g., from 1 to 5), the neutrosophic approach incorporates three dimensions: truth (T), indeterminacy (I), and falsity (F). Each response option is represented as a triplet (T, I, F), enabling a more nuanced and multidimensional evaluation of participants' attitudes. This design allows researchers to detect not only agreement or disagreement but also the degree of uncertainty associated with each judgment.

Data collection focused on variables directly linked to the defined outcome. A combination of questionnaires and surveys was employed, ensuring that each instrument integrated the neutrosophic Likert scales to maximize the richness and reliability of the data. This strategy provided a comprehensive dataset that reflects the inherent complexity of educators' perceptions and students' social competence.

The data obtained were subsequently fuzzified, transforming the neutrosophic triplets into fuzzy sets suitable for further analysis through fsQCA (Fuzzy Set Qualitative Comparative Analysis). This process preserved the multidimensional character of the responses while enabling the identification of causal configurations associated with the outcome. Such a methodological integration ensured both depth and rigor in addressing the research objectives[11].

Fuzzification : Finally, the obtained neutrosophic sets are transformed into equivalent fuzzy sets, following the procedure described in [16]. This step is essential for the subsequent analysis, allowing to handle the uncertainty and ambiguity inherent in the collected data. Let $AN = \{x, (TA(x), IA(x), FA(x)) : x \in X\}$an NS. Its equivalent fuzzy membership set is defined as $AF = \{(x, \mu A(x)) : x \in X\}$,where $\mu A(x) = s\left((TA(x), IA(x), FA(x)), (1,0,0)\right)$. Then, using the similarity equation proposed in,

$$\mu A(x) = 1 - \frac{1}{2}\left[\left(1 - T_A(x)\right) + \max\{I_A(x), F_A(x)\}\right] \quad (1)$$

Since the range of the similarity measure function is the unit interval [0,1], μA (x) ∈ [0,1] for all x ∈ X. Therefore, the membership function of the derived fuzzy set belongs to [0,1] and hence satisfies the property of a fuzzy set (FS) membership function.

This study adopted a neutrosophic–fsQCA methodological framework to identify causal configurations associated with students' social competence. The procedure was carried out in two complementary stages: (a) a Superset Analysis of Necessary and Sufficient Conditions**,** and **(b)** a Coincidence Analysis of Fuzzy Sets**.** All analyses were conducted using fsQCA 4.1 for Windows [17], and the results were replicated in R to ensure robustness and reproducibility.

Superset Analysis

The superset analysis was employed to examine whether specific conditions or combinations of conditions acted as necessary or sufficient for the outcome. Following standard fsQCA practice, two core parameters were calculated: consistency and **coverage** [18]**.**

- Consistency assesses the degree to which a condition (or combination) is a subset of the outcome:
  $$Consistency\ (Y_i \leq\ X_i) = \frac{\sum \min(X_i, Y_i)}{\sum Y_i} \quad (2)$$
- **Coverage** evaluates the empirical relevance of the condition, indicating how much of the outcome is explained by the configuration:
  $$Coverage\ (Y_i \leq\ X_i) = \frac{\sum \min(X_i, Y_i)}{\sum X_i} \quad (3)$$

Thresholds of consistency ≥ 0.90 are typically considered strong indicators of necessity or sufficiency, while coverage complements the interpretation by quantifying the explanatory power of each causal pathway.

Coincidence Analysis

To complement the superset analysis, a coincidence analysis was performed in order to explore the degree of overlap among fuzzy sets representing the conditions and the outcome. This method highlights which conditions tend to coincide more frequently and identifies bridging or mediating variables.

The coincidence index between two fuzzy sets X and Y is defined as:

$$Coincidence(X,Y) = \frac{\sum_{i=1}^{n} min(X_i,Y_i)}{\sum_{i=1}^{n} max(X_i,Y_i)} \quad (4)$$

For higher-order combinations (e.g., three or four sets), the formula generalizes as:

$$Coincidence(X,Y,Z) = \frac{\sum_{i=1}^{n} min(X_i,Y_i,Z_i)}{\sum_{i=1}^{n} max(X_i,Y_i,Z_i)} \quad (5)$$

Values close to **1** indicate strong overlap (perfect coincidence), whereas values closer to **0** indicate weak or absent coincidence. In this study, pairs of conditions generally showed stronger coincidence values (≥0.74) compared to triples or quadruple combinations, suggesting that equifinality emerges primarily through overlapping dyads rather than a single dominant configuration.

4. Results

Within the framework of the formulation of a strategic management paradigm for the Louis Pasteur Bicentennial School, the **Evolution of Students' Social Competence (ECS) was defined as an outcome of interest**. To measure this outcome and the associated causal conditions, a survey using neutrosophic Likert scales was designed. The antecedent conditions identified as crucial for the development of ECS are:

- **Interpersonal Communication (IC):** Students' skills to interact verbally and nonverbally effectively.
- **Social Interaction Experiences (SIE):** Quality and frequency of students' social interactions in diverse settings.
- **Self-esteem and Self-efficacy (SS):** Perception of one's own value and confidence in one's abilities to face social challenges.

The instrument was administered to a sample of 20 education professionals in Ecuador, including educational psychologists and teachers with extensive experience. The raw data, represented as single-valued neutrosophic sets (T, I, F), are presented below.

Table 1. Survey Data (Neutrosophic Values)

Educators	Interpersonal Communication (IC)	Social Interaction Experiences (SIE)	Self-esteem and Self-efficacy (SS)	Evolution of Competence (ECS)
1	(0.9, 0.8, 0.1)	(0.6, 1.0, 0.6)	(0.3, 0.7, 0.3)	(0.8, 0.6, 0.7)
2	(0.6, 0.6, 0.6)	(1.0, 1.0, 1.0)	(0.6, 0.1, 0.6)	(0.6, 0.6, 0.7)
3	(0.8, 0.7, 0.4)	(0.7, 0.9, 0.6)	(0.8, 0.6, 0.6)	(0.8, 0.6, 0.6)
4	(1.0, 1.0, 0.0)	(0.8, 0.8, 0.0)	(1.0, 0.9, 0.3)	(0.7, 1.0, 0.9)
5	(1.0, 0.6, 0.0)	(1.0, 0.6, 1.0)	(1.0, 0.6, 1.0)	(0.9, 0.6, 0.1)
6	(0.9, 0.9, 0.9)	(0.9, 0.9, 0.9)	(0.9, 0.9, 0.9)	(0.9, 0.9, 0.9)
7	(0.1, 0.6, 0.8)	(1.0, 0.0, 0.0)	(0.6, 0.6, 0.6)	(0.8, 0.6, 0.1)
8	(1.0, 0.9, 0.1)	(0.9, 0.9, 0.1)	(0.9, 0.9, 0.1)	(0.9, 0.9, 0.1)
9	(1.0, 1.0, 0.0)	(0.8, 0.8, 0.0)	(1.0, 0.0, 0.0)	(0.9, 0.0, 0.0)
10	(0.7, 1.0, 0.1)	(0.9, 0.4, 0.0)	(0.6, 0.9, 0.1)	(1.0, 0.0, 0.0)

Educators	Interpersonal Communication (IC)	Social Interaction Experiences (SIE)	Self-esteem and Self-efficacy (SS)	Evolution of Competence (ECS)
11	(0.4, 0.7, 0.1)	(0.3, 0.9, 0.4)	(0.8, 0.4, 0.6)	(0.4, 0.8, 0.3)
12	(0.6, 1.0, 0.6)	(0.6, 0.6, 0.1)	(0.1, 0.6, 0.7)	(1.0, 0.0, 1.0)
13	(0.7, 0.8, 0.4)	(0.8, 1.0, 0.5)	(0.7, 0.5, 0.4)	(0.7, 0.7, 0.5)
14	(0.5, 0.7, 0.2)	(0.6, 0.8, 0.6)	(0.5, 0.6, 0.5)	(0.6, 0.6, 0.4)
15	(0.9, 0.7, 0.3)	(0.7, 1.0, 0.4)	(0.6, 0.8, 0.4)	(0.8, 0.7, 0.3)
16	(0.8, 0.6, 0.5)	(0.9, 0.7, 0.3)	(0.7, 0.5, 0.6)	(0.8, 0.6, 0.4)
17	(0.6, 0.8, 0.4)	(0.7, 0.8, 0.2)	(0.5, 0.7, 0.5)	(0.7, 0.8, 0.3)
18	(0.7, 0.9, 0.3)	(0.6, 0.9, 0.2)	(0.7, 0.6, 0.6)	(0.8, 0.7, 0.3)
19	(0.6, 0.8, 0.5)	(0.8, 1.0, 0.3)	(0.6, 0.7, 0.4)	(0.7, 0.8, 0.4)
20	(0.8, 0.7, 0.4)	(0.9, 0.8, 0.2)	(0.7, 0.6, 0.5)	(0.8, 0.7, 0.4)

Step 1: Fuzzification of Neutrosophic Data

In order to apply the qualitative comparative analysis of fuzzy sets (fsQCA), it is necessary to transform the neutrosophic values (T, I, F) into values of membership in a fuzzy set, which range between 0 and 1. This process is called fuzzification and is carried out by strictly applying **Equation 1** This procedure was repeated for each of the 80 data cells (20 educators x 4 variables). The results are presented in Table 2.

Table 2. Fuzzy Values

Educators	Interpersonal Communication (IC)	Social Interaction Experiences (SIE)	Self-esteem and Self-efficacy (SS)	Evolution of Competition (ECS)
1	0.666667	0.333333	0.433333	0.500000
2	0.600000	0.333333	0.633333	0.566667
3	0.700000	0.500000	0.733333	0.733333
4	0.666667	0.666667	0.600000	0.266667
5	0.800000	0.466667	0.466667	0.766667
6	0.366667	0.366667	0.366667	0.366667
7	0.233333	1.000000	0.600000	0.766667
8	0.666667	0.666667	0.666667	0.666667
9	0.666667	0.666667	1.000000	0.966667
10	0.533333	0.833333	0.600000	1.000000
11	0.533333	0.333333	0.600000	0.433333
12	0.333333	0.766667	0.266667	0.666667
13	0.500000	0.433333	0.600000	0.500000
14	0.533333	0.400000	0.466667	0.533333
15	0.633333	0.366667	0.466667	0.600000
16	0.566667	0.633333	0.533333	0.600000
17	0.466667	0.633333	0.433333	0.533333
18	0.500000	0.500000	0.533333	0.600000
19	0.433333	0.500000	0.466667	0.466667
20	0.566667	0.633333	0.533333	0.566667
1	0.666667	0.333333	0.433333	0.500000

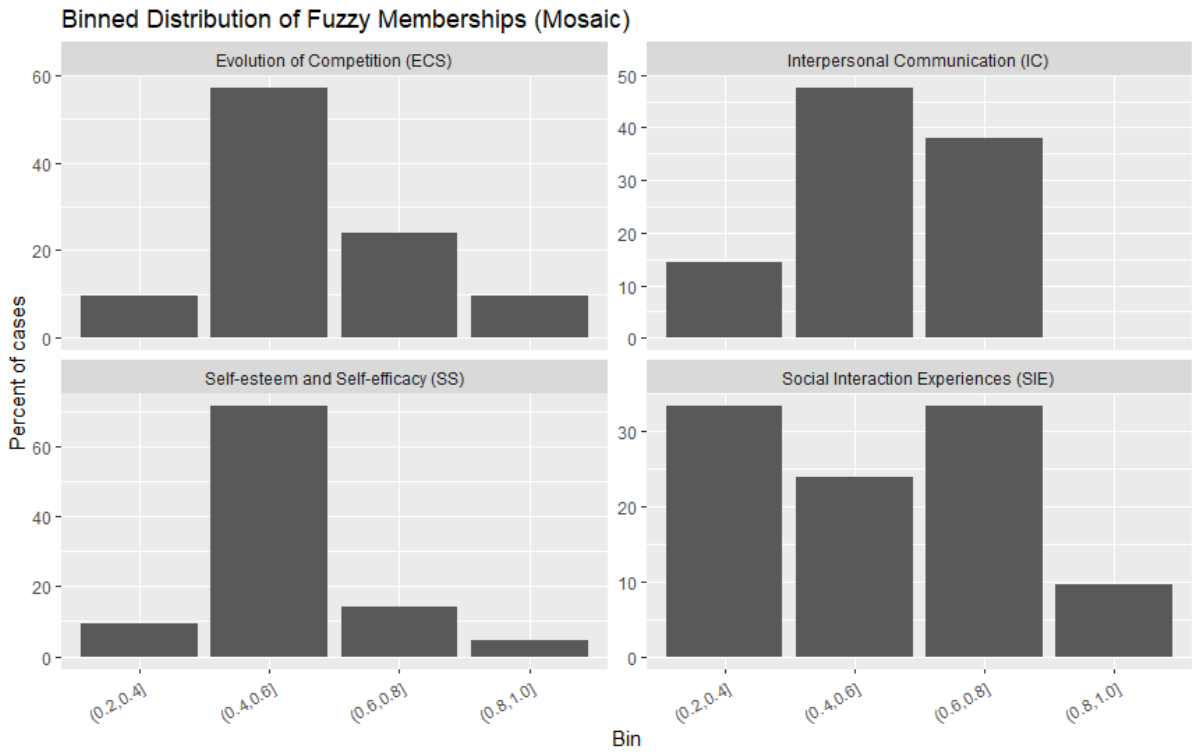

Figure 1. Fuzzy Values Distribution by Variable

Figure 1 illustrates the distribution of fuzzy membership values for each of the analyzed variables. It can be observed that the majority of cases concentrate in the intermediate ranges, particularly for Self-esteem and Self-efficacy (SS) and Evolution of Competition (ECS), which show a predominance in the 0.4–0.6 interval. Interpersonal Communication (IC) and Social Interaction Experiences (SIE) present more balanced distributions, with higher percentages in the 0.6–0.8 range. These patterns indicate that, although the variables exhibit variability, there is a tendency for educators to evaluate the competencies of students at moderate membership levels, reflecting both the presence of strengths and areas requiring further development. The mosaic view allows comparing at a glance the relative positioning of each condition and the outcome, offering an empirical foundation for the subsequent fsQCA analysis.

Coincidence Analysis of Fuzzy Sets

Table 3 presents the coincidence analysis among conditions and the outcome. The highest values were observed between IC and SS (0.815) and between SS and ECS (0.807), highlighting the central role of self-esteem as a bridging condition. By contrast, higher-order combinations (triples and quadruple) yielded moderate coincidence values (0.62–0.72), suggesting that equifinality arises primarily through overlapping dyads rather than a single dominant configuration.

Table 3. Pairwise and Higher-Order Coincidence among Conditions and the Outcome

Pair / Combination	Coincidence	Interpretation
IC ∗ SS	0.815	Strongest overlap: interpersonal communication and self-esteem tend to co-occur.
SS ∗ ECS	0.807	High coincidence: self-esteem aligns closely with the outcome.

Pair / Combination	Coincidence	Interpretation
IC ∗ ECS	0.790	Strong association between communication and the outcome.
SIE ∗ ECS	0.767	Social interaction frequently overlaps with the outcome.
SIE ∗ SS	0.745	Considerable overlap between social interaction and self-esteem.
IC ∗ SIE	0.704	Moderate-to-high overlap between communication and social interaction.
Triple: IC ∗ SS ∗ ECS	0.718	Joint overlap of IC, SS, and outcome remains strong.
Triple: SIE ∗ SS ∗ ECS	0.675	Solid coincidence of social interaction, self-esteem, and outcome.
Triple: IC ∗ SIE ∗ ECS	0.645	Lower but still meaningful joint overlap with outcome.
Triple: IC ∗ SIE ∗ SS	0.656	Good coincidence among the three conditions.
Quadruple: IC ∗ SIE ∗ SS ∗ ECS	0.622	All four sets overlap moderately; complexity reduces the degree of coincidence.

The coincidence analysis (see Table) shows that Self-esteem and Self-efficacy (SS) plays a pivotal role, presenting the strongest coincidence both with Interpersonal Communication (IC, 0.815) and with the outcome Evolution of Competition (ECS, 0.807). Social Interaction Experiences (SIE) also exhibits a high degree of overlap with SS (0.745) and with ECS (0.767), reinforcing its relevance. Pairs of conditions generally show stronger coincidence values (≥0.74) compared to triples (0.62–0.67), suggesting that equifinality emerges through multiple overlapping dyads rather than a single dominant combination. These findings highlight the mediating role of SS and the distributed influence of IC and SIE in explaining the outcome.

Superset Analysis of Necessary and Sufficient Conditions

The superset analysis was conducted to identify conditions and combinations of conditions that behave as necessary or sufficient for the outcome. Table 2 summarizes the results, reporting consistency and coverage values for each configuration. Consistency values above the 0.90 threshold indicate that the conditions are almost always present when the outcome occurs, while coverage values capture the empirical relevance of each pathway. The analysis reveals that multiple equifinal solutions exist, underscoring that no single factor exclusively explains the outcome. Instead, different combinations of interpersonal communication, social interaction, and self-esteem are capable of producing the same result, highlighting the complex and conjunctural nature of the phenomenon.

Table 4. Interpretation of Superset Analysis Results

Condition / Combination	Consistency	Coverage	Interpretation
IC ∗ SIE ∗ SS	0.964	0.707	Very strong sufficiency; when all three conditions are present, the outcome almost always occurs (70% of cases).
SIE ∗ SS	0.966	0.745	Strong equifinal pathway; social interaction and self-esteem together are nearly always sufficient for the outcome.
IC ∗ SS	0.956	0.784	Another strong pathway; communication combined with self-esteem strongly aligns with the outcome.

Condition / Combination	Consistency	Coverage	Interpretation
IC ∗ SIE	0.958	0.721	Consistent joint effect; though slightly less coverage, it shows that communication plus social interaction also lead to the outcome.
SIE (alone)	0.916	0.825	High consistency and broad coverage; indicates that social interaction alone approaches necessity for the outcome.

Note. IC = Interpersonal Communication; SIE = Social Interaction Experiences; SS = Self-esteem and Self-efficacy. Thresholds commonly used: consistency ≥ 0.90 = necessary/sufficient condition; coverage indicates empirical relevance.

The superset analysis revealed several equifinal pathways with high consistency scores. As shown in Table 4, the combination of SIE and SS (consistency = 0.966; coverage = 0.745) and the combination of IC and SS (consistency = 0.956; coverage = 0.784) emerge as strong sufficient conditions for the outcome. Moreover, the condition SIE alone demonstrates a consistency of 0.916 and coverage of 0.825, approaching the threshold typically considered for necessity. These results highlight the central role of self-esteem and social interaction, either alone or in combination with interpersonal communication, in explaining the presence of the outcome.

5. Discussion

This section discusses the main findings derived from the integration of neutrosophic logic and fuzzy set Qualitative Comparative Analysis (fsQCA) in the context of strategic school management. The aim was to identify causal configurations that lead to the development of students' social competence. By applying a superset analysis and a coincidence analysis, the study sheds light on how different combinations of interpersonal communication, social interaction, and self-esteem operate as necessary or sufficient conditions for achieving the desired outcome.

One of the most significant findings is the central role of Self-esteem and Self-efficacy (SS) [19]. Across both analytical approaches, SS consistently emerged as the most critical condition. Its high consistency values, both alone and in combination with other conditions, suggest that fostering students' self-confidence is essential for the development of social competence. This supports the argument that personal beliefs about self-worth and capability act as foundational prerequisites for positive social behavior. In practice, this implies that educational strategies must go beyond purely academic training and include psychosocial support mechanisms.

Another key insight is the equifinal nature of the causal pathways. The analysis revealed several highly consistent configurations—such as SIE ∗ SS and IC ∗ SS—indicating that different routes can lead to the same outcome. This reflects the complexity of educational systems and aligns with the tenets of complexity theory, which reject linear causality. For school leaders, this means that there is no single "correct" strategy to enhance social competence; rather, multiple combinations of conditions can be equally effective. This insight calls for a more flexible and context-sensitive approach to strategic management, allowing schools to adapt interventions to their specific realities.

From a methodological standpoint, the integration of neutrosophic logic into fsQCA represents a valuable contribution. The use of neutrosophic Likert-type data enabled the analysis to account for degrees of truth, falsity, and indeterminacy in educators' perceptions, which are often neglected in conventional approaches. This hybrid method offers a richer, more nuanced picture of the causal complexity underlying social competence development. It also opens the door for future research to experiment with similar integrations in other areas of educational and social research.

Finally, the results have practical implications for educational policy. Programs designed to enhance interpersonal communication and social interaction should be coupled with efforts to build students'

self-esteem. Such integrated strategies are likely to yield the strongest and most consistent improvements in social competence. Moreover, in resource-limited settings, identifying the most impactful combinations can help policymakers prioritize interventions that deliver the greatest benefits with the least investment [20, 21].

In conclusion, the findings of this study underscore the need to view student social competence as the product of multiple interacting conditions, rather than the result of isolated factors. The combination of neutrosophic modeling and fsQCA proves to be a powerful tool for uncovering the configurational logic of complex educational outcomes.

6. Conclusions

This study applied a neutrosophic–fsQCA framework to analyze the causal configurations that explain students' social competence in the context of strategic school management. By transforming neutrosophic Likert triplets into fuzzy sets and applying both superset and coincidence analyses, the research was able to capture not only truth and falsity but also the indeterminacy present in educators' perceptions. This methodological integration enriches the understanding of causal complexity in education and provides a replicable protocol for handling uncertainty in social research.

The results of the superset analysis revealed multiple equifinal pathways, confirming that social competence is not explained by a single factor but rather by different constellations of conditions. Configurations such as SIE ∗ SS and IC ∗ SS proved to be strong sufficient routes, while SIE alone approached necessity. The coincidence analysis complemented these findings by showing that Self-esteem and Self-efficacy (SS) functions as a pivotal bridging condition, with the highest overlap both with Interpersonal Communication (IC) and with the outcome. Stronger overlaps in dyads compared to triples or quadruples suggest that impactful dynamics in educational settings often emerge through pairs of conditions rather than more complex combinations.

From a practical perspective, these findings highlight that strategic school management should prioritize interventions that simultaneously strengthen communication, foster social interaction, and enhance self-esteem. Such integrated approaches are more likely to yield consistent and sustainable improvements in students' social competence. At the same time, the methodological contribution of combining neutrosophic modeling with fsQCA and coincidence analysis opens new avenues for future research, offering a powerful analytical toolkit to address the configurational and uncertain nature of educational and social phenomena.

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