Multicriteria Algorithms with Applications

Journal Homepage: sciencesforce.com/mawa

Multicriteria. Algo. Appl. Vol. 7 (2025) 24–36

Paper Type: Original Article

# Using Neutrosophic Statistical Methods in Research on the Negative Effects of Obstacles to Learning on Teaching Excellence

**Pedro Fernando Mite Reyes** [1,*] **and Carlos Fernando Morales Vera** [1]

[1] Ministry of Education, Ecuador.
Emails: pedro.mite@educacion.gob.ec, fernando.morales@educacion.gob.ec.

**Received:** 05 Aug 2024 **Revised**: 13 Jan 2025 **Accepted**: 17 Apr 2025 **Published**: 18 Apr 2025

## Abstract

This article explores a core challenge: how learning impediments adversely impact the quality of teaching, framing as its central question the analysis of the negative effects these barriers generate on educational excellence. To this end, the difficulties faced by students and teachers, ranging from cognitive limitations to unfavorable environments, are examined in detail, using Plithogenic statistics as a basis. Although previous research on the topic exists, it often lacks an integrative approach that considers the ambiguity and multiple dimensions of educational data. This work addresses this gap by employing an innovative method that captures the inherent complexity of learning obstacles. Through the analysis of Plithogenic statistics, which combine elements of certainty, uncertainty, and contradiction, patterns and trends are explored that reveal the true scope of these problems in the educational field. The relevance of this study lies in its timeliness: in a world where education faces growing challenges, such as inequality and digitalization, understanding these obstacles is essential for designing effective solutions. The main findings show that barriers to learning not only reduce academic performance but also erode the overall quality of teaching, affecting teachers and students alike. Furthermore, the use of Plithogenic statistics allows for the identification of key factors that traditional approaches overlook. In terms of contribution, this research brings a novel theoretical perspective to the field of pedagogy while also offering practical applications, such as strategies to mitigate negative effects in the classroom. Thus, the study not only enriches the understanding of educational dynamics but also provides concrete tools to improve teaching in real-life contexts, promoting more inclusive and effective education.

**Keywords:** Obstacles to Learning; Teaching Excellence; Negative Effects; Plithogenic Statistics; Educational Quality; Barriers; Methodology; Analysis; Education; Uncertainty.

## 1 | Introduction

Education stands as a vital foundation for the progress of any society, with its quality directly shaping the economic, social, and cultural development of nations. Yet, a variety of learning barriers can hinder this quality, constraining students' potential and reinforcing inequalities [1]. Spanning socioeconomic challenges to inadequacies in educational infrastructure, these barriers pose an intricate, multifaceted problem that calls for prompt and strategic action. Rather than existing in isolation, learning barriers often intertwine, forming a complex web of challenges that can be tough to unravel. For instance, limited educational resources might connect to unstable home environments, which in turn dampen students' motivation and academic achievement. Such interrelationships emphasize the importance of a broad, multidimensional strategy to tackle learning barriers [2]. One crucial consideration is the array of factors that affect learning. Elements like

Corresponding Author: pedro.mite@educacion.gob.ec
https://doi.org/10.61356/j.mawa.2025.7535

poverty, domestic violence, malnutrition, and restricted access to information technologies can significantly impair students' learning abilities. These influences extend beyond academics, impacting self-esteem and mental health, and perpetuating a hard-to-break cycle of disadvantage. In-depth analysis of learning barriers allows for the detection of patterns and trends that might otherwise remain hidden. This analysis is essential for crafting targeted interventions that meet students' specific needs [3]. Recent studies, for example, have highlighted the notable benefits of psychoeducational support programs and family interventions in overcoming certain learning barriers. Additionally, enacting inclusive educational policies is critical to guaranteeing all students access to quality education. This entails not just enhancing school facilities and providing sufficient resources, but also fostering a learning environment responsive to students' diverse needs, including cultural and linguistic diversity as well as varying abilities and learning styles.

Educators are central to this effort. Teachers require training to recognize and address learning barriers, along with support to employ effective teaching strategies [4]. Ongoing professional development and training for educators are vital for elevating educational quality and ensuring students receive the necessary support. Community participation also plays a key role in overcoming learning barriers. Schools should collaborate with families, local organizations, and authorities to cultivate a supportive setting that fosters both learning and students' overall growth. Such partnerships might encompass mentoring programs, extracurricular activities, and social-emotional support services. Technology is another significant factor in contemporary education. Access to information and communication technologies can create new learning possibilities and aid in overcoming certain barriers. However, ensuring all students can access and effectively use these tools is critical [5]. The digital divide persists as a major obstacle in many areas, requiring targeted efforts to achieve equitable education. Lastly, it's imperative to regularly assess the effectiveness of educational interventions and adapt strategies accordingly. Research and data analysis should be core elements of the educational process, enabling flexible responses to the evolving needs of students and communities. This evidence-based approach helps identify and replicate best practices across diverse contexts. In summary, examining the detrimental effects of learning barriers on educational quality is key to developing and applying strategies that advance equitable, high-quality education. Addressing these barriers demands a comprehensive approach that accounts for the diverse, interconnected factors influencing learning, alongside collaboration among educators, families, communities, and policymakers. Only through persistent, collective effort can we ensure every student has the opportunity to fulfill their potential.

# 2 | Related Works

## 2.1 | Effects On Teaching Excellence

Learning barriers represent a primary obstacle within today's educational landscape. These barriers manifest in diverse ways, encompassing cognitive and emotional challenges as well as economic and social hurdles. Recognizing and addressing them is vital to ensuring every student can unlock their full potential. In this context, understanding the essence of these barriers and crafting effective solutions to alleviate their impact is imperative [6]. To begin, it's essential to acknowledge that learning barriers vary widely. Some are inherent to the individual, such as attention deficits, dyslexia, or autism spectrum disorders, necessitating tailored interventions and curriculum adjustments to enable full participation in education. Conversely, extrinsic barriers—like insufficient educational resources, adverse socioeconomic conditions, and limited family support—demand attention through inclusive policies and increased resource investment. Tackling learning barriers calls for a comprehensive strategy that accounts for all facets of the issue. Focusing solely on classroom efforts is insufficient; it requires engaging the community, families, and educational policymakers. Such collaboration is critical to establishing a robust support system that nurtures student learning and growth [7]. This can involve introducing mentorship initiatives, extracurricular programs, and emotional and psychological support services. A pivotal element in this effort is the ongoing training of educators. Teachers need to be equipped to detect and respond to the diverse challenges students encounter. This preparation goes beyond acquiring specialized knowledge and skills—it also entails fostering empathy and adaptability.

Educators should tailor their teaching approaches to students' unique needs, cultivating an inclusive and engaging classroom environment.

Technology offers valuable opportunities to address learning barriers. Digital tools and online platforms can personalize education and provide extra assistance to students who struggle. Yet, ensuring universal access to these technologies and proficiency in their use is critical [8]. The digital divide remains a significant impediment, particularly in underserved communities, and must be bridged to promote equitable education. Assessing the effectiveness of educational interventions is equally important to pinpoint the most successful strategies and adapt them across contexts. Research and data analysis should be embedded in the educational framework, enabling responsive adjustments to students' evolving needs. Evidence-based policies are key to designing and executing programs that deliver meaningful results. Furthermore, the role of socioeconomic factors in learning barriers cannot be overlooked. Poverty, lack of access to basic services, and food insecurity profoundly affect academic performance. Addressing these requires a broad approach that extends beyond education, incorporating social and economic policies to enhance family living conditions. Community involvement in education is another essential factor in overcoming learning barriers. Schools should collaborate closely with families and local organizations to foster a supportive environment that enhances students' holistic learning and development [9]. This might include participation in school events, volunteer efforts, and creating community support networks.

Lastly, fostering a culture of inclusion and respect within education is fundamental. Every student, regardless of their abilities or background, should feel valued and supported. This demands not only inclusive policies but also the cultivation of positive attitudes toward diversity and difference. Inclusive education is both a matter of social justice and a practical means to improve outcomes and build fairer, more cohesive societies. Learning barriers pose an intricate, multifaceted challenge that requires a unified, collaborative response. Addressing both intrinsic and extrinsic barriers involves all stakeholders in the educational process. Continuous teacher training, technology integration, regular evaluation of interventions, and community engagement are crucial to establishing an inclusive, high-quality educational setting. Only through sustained, collective effort can we ensure all students have the chance to realize their potential and contribute to creating more just and equitable societies.

## 2.2 | Plithogenic Statistics (PS)

Plithogenic statistics (PS) is an advanced, multifactorial methodology for data analysis that is applied in various fields, including education. This approach allows for a deeper and more detailed understanding of how multiple variables interact, which is especially useful for investigating complex phenomena such as learning barriers. Next, the impact and advantages of using Plithogenic statistics in the study of learning barriers and the quality of education are analyzed and assessed. First, Plithogenic statistics allow for the simultaneous analysis of multiple factors that affect learning [10-12]. Unlike traditional methods that usually focus on individual variables, PS consider the interactions between various variables such as the socioeconomic environment, the quality of educational infrastructure, and the individual characteristics of students. This holistic approach provides a more complete view of the challenges students face and allows for the identification of patterns and correlations that would otherwise go unnoticed [13,14].

The use of PS in education also facilitates the identification of subgroups of students who are particularly vulnerable to certain learning barriers. For example, through Plithogenic analyses, it can be discovered that students in rural areas face greater obstacles due to a lack of technological and transportation resources. This information is crucial for designing specific, targeted interventions that address the particular needs of these subgroups, thereby optimizing resource use and improving educational outcomes. Furthermore, PS are useful for evaluating the long-term impact of learning barriers. Many times, the effects of these barriers are not immediately visible and can manifest years later in terms of employment opportunities, income, and general well-being [15-17]. By analyzing longitudinal data, PS makes it possible to track these effects over time and

understand how and when to intervene to mitigate negative consequences. This temporal approach is vital to design sustainable and effective educational policies.

Another notable aspect of Plithogenic statistics is its ability to handle large volumes of data and perform complex analyzes efficiently. With increasing access to detailed, real-time educational data, PSs can process and analyze this information quickly and accurately. This allows educational researchers and policy makers to make informed decisions based on solid evidence, which is essential for the continuous improvement of educational systems [18] The application of PS also promotes interdisciplinary collaboration. Since learning barriers are multifaceted and encompass economic, social, psychological and pedagogical aspects, an approach that integrates knowledge from various disciplines is necessary. Plithogenic statistics facilitate this integration by providing a common platform for the analysis of complex data, thus fostering collaboration between experts from different fields and enriching the decision-making process. However, it is important to note that the implementation of PS in education is not without challenges. One of the main obstacles is the need for high-quality and detailed data. The collection and maintenance of this data requires significant investments in technological infrastructure and the training of specialized personnel. Furthermore, it is crucial to ensure data privacy and security, especially when it comes to sensitive information related to students.

Another challenge is the need for ongoing training for education professionals - Effective use of PS requires advanced skills in data analysis and understanding of complex statistical methodologies - This implies the need for training and professional development programs for teachers, administrators and educational policy makers, ensuring that they can take full advantage of the benefits of Plithogenic statistics - Despite these challenges, the potential benefits of PS in education are significant - By providing a deeper and more detailed understanding of learning barriers and their interactions, SPs allow more effective and equitable interventions to be designed and implemented [19-22] This not only improves the quality of education, but also contributes to reducing inequalities and promoting social justice. In conclusion, Plithogenic statistics represents a powerful and advanced tool for the analysis of educational data. Their ability to handle multiple variables, identify complex patterns, and evaluate long-term impacts makes them a valuable methodology for studying and overcoming learning barriers. Through careful implementation and ongoing training, PSs can transform the way we understand and address educational challenges, contributing to a more inclusive and high-quality education system.

There are several subclasses of Plithogenic Statistics which are shown:

- Multivariate statistics,
- Neutrosophic Plithogenic Statistics,
- Plithogenic indeterminate statistics,
- Plithogenic intuitionistic fuzzy statistics,
- Fuzzy statistics of Plithogenic images,
- Plithogenic spherical fuzzy statistics,
- And in general: Plithogenic statistics (diffuse extension).

In a neutrosophic population, each element has a triple probability of affiliation$(T_j, I_j, F_j)$, where$T_j, I_j, F_j \in [0,1]$ similar to that$0 \leq T_j + I_j + F_j \leq 3$.

If we assume that we must have the data set $(T_j, I_j, F_j)$for$j = 1, 2, \dots, n$, where $n$ is the sample size, then the average probability of all the sample data is calculated using Eq. (1).

$$\frac{1}{n}\sum_{j=1}^{n}(T_j, I_j, F_j) = \left(\frac{\sum_{j=1}^{n} T_j}{n}, \frac{\sum_{j=1}^{n} I_j}{n}, \frac{\sum_{j=1}^{n} F_j}{n}\right) \quad (1)$$

In this investigation, we also consider some operations in the form of neutrosophic numbers. These ways of representing indeterminacy, under certain conditions, are equivalent to working with intervals.

**Definition 1:** ([23-25]) a neutrosophic number N is defined as a number as follows:

$$N = d + I \quad (2)$$

Where d is called *the determinate part* and I is called *the indeterminate part.*

Given$N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ are two neutrosophic numbers, some operations between them are defined as follows:

$N_1 + N_2 = a_1 + a_2 + (b_1 + b_2)I$ (Addition);

$N_1 - N_2 = a_1 - a_2 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

Furthermore, the arithmetic operations between intervals are important in this paper, which is summarized below ([26-28]):

Given $I_1 = [a_1, b_1]$and $I_2 = [a_2, b_2]$ We have the following operations between them:

$I_1 \leq I_2$If and only if$a_1 \leq a_2$ and $b_1 \leq b_2$.

$I_1 + I_2 = [a_1 + a_2, b_1 + b_2]$ (Addition);

$I_1 - I_2 = [a_1 - b_2, b_1 - a_2]$(Subtraction),

$I_1 \cdot I_2 = [\min\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}, \max\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}]$ (Product),

$I_1 / I_2 = I_1 \cdot (1/I_2) = \{a/b: a \in I_1, b \in I_2\}$, always that $0 \notin I_2$(Division).

## 3 | Results and Discussion

The research focused on a population of 95 educators. Using non-probability sampling was applied at the discretion of the researcher. For data collection, the survey was used as a quantitative research method, and the data were collected using a previously prepared questionnaire. This questionnaire, developed according to the objectives and dimensions of the dependent variable, contains approximately 30 items. To evaluate the quality of education through a survey, it is important to consider various dimensions that address different aspects of the educational process. Below are four key dimensions for an education quality survey:

1. Academic dimension:
    - Curriculum and Content: Relevance and updating of curricular content.
    - Teaching Methodology: Effectiveness of the teaching methods used by teachers.
    - Assessment and Feedback: Assessment systems and the quality of feedback provided to students.
    - Academic Achievement: Levels of performance and fulfillment of educational objectives.
2. Dimension of the School Environment:
    - Infrastructure: Quality of school facilities (classrooms, laboratories, libraries).
    - Educational Resources: Availability and accessibility of teaching and technological materials.
    - Learning Environment: Safety, cleanliness, and comfort of the school environment.

- School Climate: Relationships between students, teachers, and administrative staff.

3. Dimension of Comprehensive Student Development:
   - Psychosocial Support: Availability of guidance and emotional support services.
   - Extracurricular Activities: Opportunities for participation in sports, arts, and other extracurricular activities.
   - Training in Values and Citizenship: Integration of values and civic education in the curriculum.
   - Student Wellbeing: Overall satisfaction and well-being of students at school.
4. Participation and Governance Dimension:
   - Parent and Community Involvement: Level of parental and community involvement in school life.
   - School Management: Efficiency and transparency in school administration.
   - Educational Policies: Implementation and effectiveness of educational policies at the school level.
   - Communication and Transparency: Fluency and effectiveness of communication between the school and interested parties.

These dimensions provide a broad and holistic framework to evaluate the quality of education, allowing us to obtain a complete and detailed vision of the different aspects that influence the educational process and the well-being of students.

The teachers were evaluated taking into account their accumulated experience, and the possible limitations they could have in understanding neutrosophic methods were considered. For this reason, they were asked to express their opinions using ranges of values rather than assigning a single number on a continuous scale from 0 (Never) to 10 (Always). Each participant defined their intervals as $I_i = [a_{iL}, a_{iU}]$. To ensure the validity of the instruments used for data collection, validation was carried out through the judgment of experts with doctorates. The reliability of these instruments was evaluated by analyzing the Cronbach 's Alpha coefficient, thus confirming the reliability of the instrument used. The last step of the process consisted of administering the survey to the members of the experimental group, collecting all the necessary data for subsequent analysis by the researchers. The detailed steps followed in this process are as follows:

1. Different variables are specified. for the dimensions to measure:

$S = \{s_1, s_2, \ldots, s_{34}\}$denotes the set of teachers in the study group.

$\tilde{S} = \{\tilde{s}_1, \tilde{s}_2, \ldots, \tilde{s}_{34}\}$denotes the set of teachers in the control group.

$d = \{d_1, d_2, d_3, d_4\}$denotes the set of dimensions to be measured, such that:

$d_1$: Symbolizes the " Academic Dimension " dimension,

$d_2$: Symbolizes the dimension " Dimension of the School Environment ",

$d_3$: Symbolizes the dimension " Dimension of the Comprehensive Development of the Student ",

$d_4$: Symbolizes the dimension " Participation and Governance Dimension ".

Each of these elements is a set of elements in itself, where:

$d_1 = \{d_{11}, d_{12}, \ldots, d_{17}\}$is the set of elements of the first dimension ( $d_{1j}$represents the 1st item Dimension),

$d_2 = \{d_{21}, d_{22}, \ldots, d_{26}\}$is the set of elements of the second dimension ( $d_{2j}$represents the 2nd item Dimension),

$d_3 = \{d_{31}, d_{32}, \ldots, d_{37}\}$is the set of elements of the third dimension ( $d_{3j}$represents the 3rd article Dimension),

$d_4 = \{d_{41}, d_{42}, \ldots, d_{47}\}$It is the set of elements of the fourth dimension ( $d_{4j}$represents the 4th Article Dimension).

In this way, the evaluations for each item are represented by:

$I_{ijk} = [a_{ijkL}, a_{ijkU}]$, which is the evaluation of the economic in the target group for the k $^{th}$ item of the j $^{th}$ dimension.

The equivalent notation for the control group is $\tilde{I}_{ijk} = [\tilde{a}_{ijkL}, \tilde{a}_{ijkU}]$.

2. The dimension scores were obtained for each respondent and each of the dimensions using the following expression:

$$D_{ji} = \sum_{k=1} I_{ijk} \quad (3)$$

$D_{ji}$is the score of a variable or dimension j for respondent i. This score is obtained by the arithmetic sum of all the k items of the variable or dimension j, answered by respondent i, using the sum of intervals.

Equivalently, we have the results for the control group:

$$\tilde{D}_{ji} = \sum_{k=1} \tilde{I}_{ijk} \quad (4)$$

3. Since the dimensions and variables have different numbers of elements, the scores are transformed into a range from 0 to 100 using the following expression for the study group:

$$D_{ji}^{*} = \frac{D_{ji} - \text{min punt theoric } D_j}{\text{max punt theoric } D_j - \text{min punt theoric } D_j} * 100 \quad (5)$$

Where: $D_{ji}^{*}$is the transformed score for variable or dimension j of respondent i.

In the same way, we have Equation 6 for the control group.

$$\tilde{D}_{ji}^{*} = \frac{\tilde{D}_{ji} - \text{min punt theoric } \tilde{D}_j}{\text{max punt theoric } \tilde{D}_j - \text{min punt theoric } \tilde{D}_j} * 100 \quad (6)$$

These transformations allow the scores of the variables or dimensions to have the same range of values despite their number of elements so that 0 represents the minimum level and 100 the maximum level. That is, these new scores are the proportions of the dimensions or value of the variable by the respondents.

$\overline{D}_j^{*}$ Denotes the average of the results for the j$^{th}$ dimension for the study group and is calculated by the following formula:

$$\overline{D}_j^{*} = \frac{\sum_{i=1}^{34} D_{ji}^{*}}{34} \quad (7)$$

Equivalently for the control group:

$$\overline{\tilde{D}}_j^{*} = \frac{\sum_{i=1}^{34} \tilde{D}_{ji}^{*}}{34} \quad (8)$$

As the change occurs before and after passing the group study program, formula 9 is used:

$$\overline{\Delta}_j^{*} = \overline{D}_{j\text{after}}^{*} - \overline{D}_{j\text{before}}^{*} \quad (9)$$

Where $D^*_{jiafter}$denotes the scores of the study group after passing the program, while $D^*_{jibefore}$the previous results are.

While:

$$\bar{\bar{\Delta}}^*_j = \bar{D}^*_j - \bar{\bar{D}}^*_j \quad (10)$$

Denotes the difference between the averages of the group to be studied with the control group.

Once the indices used to measure these results were defined, calculations were made that indicate the following, as can be seen in the following Figures 1-4:

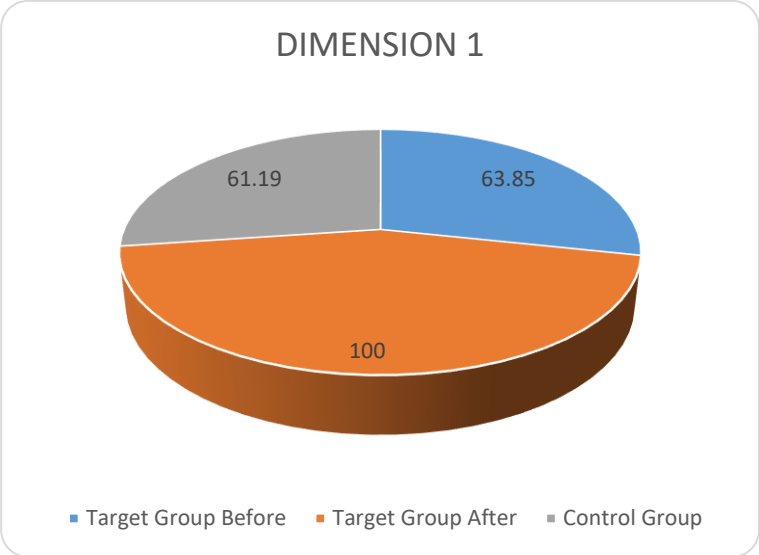


**Figure 1.** Average results of the target group with and without barriers and from the control group for Dimension 1.

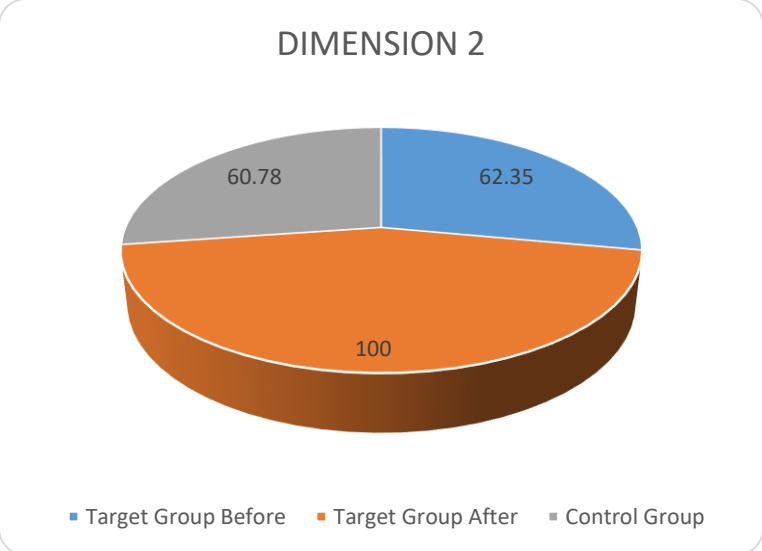


**Figure 2.** Results of the average of the target group with and without barriers and of the control group for Dimension 2.

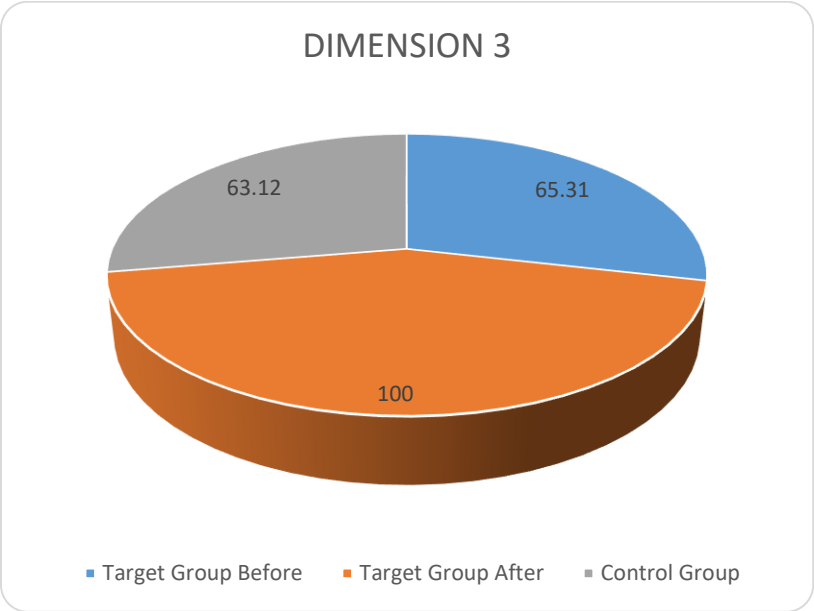


**Figure 3.** Results of the average of the target group with and without barriers and of the control group for Dimension 3.

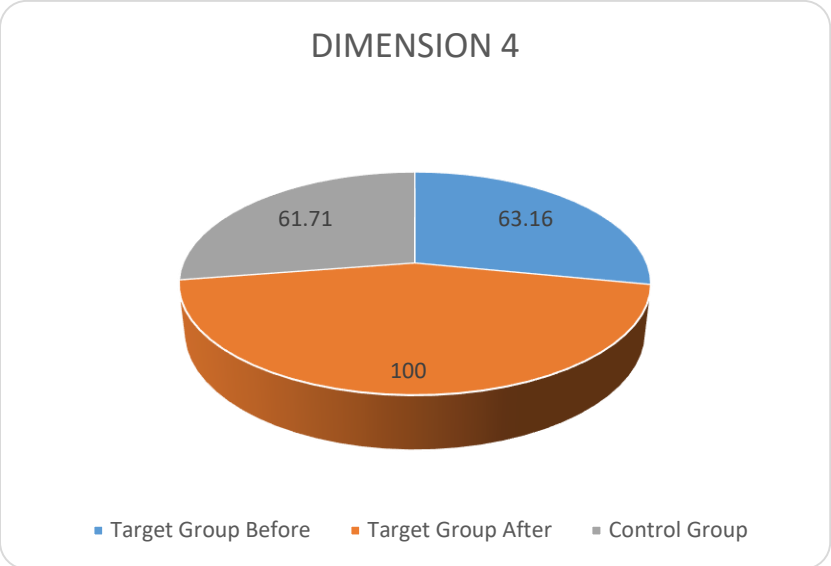


**Figure 4.** Results of the average of the target group with and without barriers and of the control group for Dimension 4.

Thus using the difference between intervals we have:

- $\overline{\Delta}_1^* = [100, 100] - [63.85, 61.19] = [36.15, 38.81]$,
- $\overline{\Delta}_2^* = [100, 100] - [62.35, 60.78] = [37.65, 39.22]$,
- $\overline{\Delta}_3^* = [100, 100] - [65.31, 63.12] = [34.69, 37.88]$,
- $\overline{\Delta}_4^* = [100, 100] - [63.16, 61.71] = [36.84, 38.29]$.

On the other hand, the results for $\overline{\overline{\Delta}}_j^*$ are as shown below:

- $\overline{\overline{\Delta}}_1^* = [100, 100] - [66.16, 69.71] = [33.84, 30.29]$,
- $\overline{\overline{\Delta}}_2^* = [100, 100] - [63.34, 62.35] = [36.66, 37.65]$,

- $\overline{\widetilde{\Delta}}_3^*= [100, 100] - [64.33, 61.12] = [35.67, 38.88]$,
- $\overline{\widetilde{\Delta}}_4^*= [100, 100] - [65.87, 64.19] = [34.13, 35.81]$.

As can be seen, the values always showed improvements of around 30% or more, both when the target group was compared with itself before and after the program, and when compared with the control group.

To obtain a result that encompasses all the dimensions in a single final value, formula 11 will be used:

$$\min([a_1, b_1], [a_2, b_2]) = [\min(a_1, a_2), \min(b_1, b_2)] \quad (11)$$

In this case,

$D^* = \min([63.85, 61.19], [62.35, 60.78], [65.31, 63.12], [63.16, 61.71]) = [62.35,60.78]$ It is the result of the target group before the educational reforms.

After passing the performance audits the overall result is $[100, 100]$.For the control group this is

$\widetilde{D}^* = \min([66.16, 69.71], [63.34, 62.35], [64.33, 61.12], [65.87, 64.19]) = [63.34,61.12]$.

Finally, we obtained the result for the "quality of education" test, before and after for the objective group and the control group. These are shown in Figure 5:

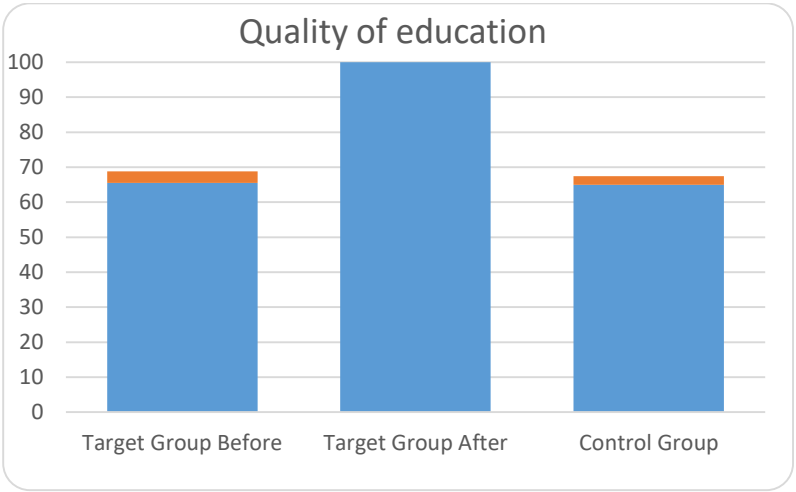


**Figure 5.** Average results of the target group with barriers and without barriers and of the control group for "poor quality of Education".

In this case, we will calculate the difference in absolute value to avoid negative numbers in the calculation of the relationship between performance audits and the quality of management of public organizations. That is, equation 12 will be used.

$$[a_1, b_1] \ominus [a_2, b_2] = [\text{abs}(a_1 - b_2), \text{abs}(b_1 - a_2)] \quad (12)$$

In this case, it is:

$[62.35,60.78] \ominus [63.34,61.12] = [1.23, 2.56]$ This is the result of comparing "the poor quality of education" with the aggregation of the four dimensions that represent "learning barriers." This represents a difference of less than 5.1% between both results.

On the other hand, $[100, 100] \ominus [100, 100] = [0, 0]$for both variables after the program. This suggests a high and positive correlation between "learning barriers" and "poor quality of education".

The comparison between the values [62. 35, 60. 78] and [63. 34, 61. 12], which resolves the difference [1. 23, 2. 56], offers a fascinating insight into the impact of the quality of education concerning learning barriers. This

difference, which is less than 5 1%, suggests that there is a slight variation between the two measurements. This small margin could be indicative that, despite attempts to improve educational quality, learning barriers continue to persistently influence educational outcomes. This analysis invites reflection on the effectiveness of the measures taken to address learning barriers. The narrow difference between the figures reflects a reality in which barriers continue to play a significant role. Despite efforts to overcome these barriers, the quality of education has not shown substantial improvement. This shows that the solutions implemented so far may not be sufficient to comprehensively address educational challenges.

On the other hand, the result [100,100] ⊖ [100,100] = [0, 0], which is observed in the context of the two variables after the program, presents a different perspective. The high and positive correlation between "learning barriers" and "poor quality of education" indicates that, in this case, there is no significant difference between the two variables after the intervention. This suggests that learning barriers and poor educational quality are intrinsically related and that improvements in one could be reflected in the other. This finding is fundamental to understand the relationship between these two variables. If both variables behave identically after the program, we could infer that the interventions carried out have had a uniform impact in both areas. This may be a sign that the program has effectively addressed both learning barriers and poor educational quality, thus achieving synchronization in its evolution. However, this high, positive correlation does not necessarily imply that the program has been completely successful in resolving the underlying problems. Rather than a qualitative improvement, the correlation suggests that the two variables have been adjusted in parallel. It is crucial to consider that a high correlation does not always reflect a definitive solution, but rather an alignment in patterns of change.

In this context, it is imperative to question whether the solution provided is sufficient to generate a significant change in educational quality. Equality in measurements after the program could be the result of superficial adjustments rather than deep reforms. This raises the need to further evaluate interventions and their real effects on educational barriers and quality. The complexity of the relationship between learning barriers and educational quality requires a more nuanced analysis. The equality of results could mask underlying problems that need to be addressed with more specific and detailed strategies. Deep understanding of individual barriers and their impacts is essential to design more effective interventions. In summary, the analysis of the differences and correlations between the results before and after the program reveals both achievements and limitations. The slight difference in the initial measurements and the subsequent high correlation suggest that, although progress has been made, there is still work to be done. The need for deeper and more personalized approaches remains relevant to achieve real and lasting improvement in educational quality. This analysis shows that the path to quality education is complex and requires constant attention. The data suggest that, although some progress has been made, it is essential to continue evaluating and adjusting strategies to ensure that learning barriers are effectively overcome and that educational quality is significantly raised.

# 4 | Conclusion

The examination of the outcomes derived from comparing the ranges [62.35, 60.78] and [63.34, 61.12], which yields a difference of [1.23, 2.56], indicates a minor disparity that prompts significant questions regarding the quality of education in light of persistent learning barriers. Although this variation is below 5.1%, it implies that, despite initiatives aimed at enhancing educational standards, these barriers continue to exert a considerable impact on academic results. This observation suggests that the current interventions might not fully address the complexities of these challenges. The ongoing presence of learning barriers, even with implemented measures, underscores the necessity for a thorough reassessment of existing strategies. The lack of substantial progress in educational quality points to the possibility that the solutions employed thus far may lack the depth required to address the root causes effectively. This raises a critical question: have the reforms been sufficient, or have they merely served as superficial fixes that fail to address the underlying issues?

Conversely, the result of [100, 100] ⊖ [100, 100] = [0, 0] reveals a strong positive correlation between "learning barriers" and "poor educational quality" following the program. This finding indicates that these two factors have progressed in tandem, potentially suggesting that the program has succeeded in aligning the changes observed in both domains. However, this significant correlation does not inherently mean a complete resolution of the deeper issues. While the strong positive correlation might indicate synchronized patterns of change, it should not be taken as definitive evidence of success in overcoming the challenges. Instead of reflecting a genuine enhancement in educational quality, this alignment could imply that both learning barriers and educational quality have shifted in parallel without meaningful improvement in absolute terms. Consequently, it becomes vital to evaluate whether the interventions have been robust enough to drive substantial change in educational outcomes. The parity observed in post-program measurements might obscure persistent issues that demand more targeted and detailed attention. The current approach may fall short of addressing the core problems and achieving lasting improvements in educational quality. A more comprehensive evaluation of the interventions is recommended, one that transcends superficial adjustments and delves into a detailed understanding of specific barriers and their unique effects. Such an approach is essential for crafting more precise and effective strategies.

A finer, more nuanced analysis is required to pinpoint areas still in need of focus and development. In conclusion, while the analysis demonstrates some progress, it also exposes notable shortcomings. The slight variation in initial measurements and the strong correlation observed post-program suggest that, although strides have been made, further efforts are necessary. The demand for deeper, more tailored strategies remains critical to securing genuine, sustainable advancements in educational quality. This study highlights the intricate journey toward achieving high-quality education and emphasizes the importance of ongoing, critical scrutiny. The data indicates that, while some headway has been achieved, continued evaluation and refinement of strategies are imperative to effectively surmount learning barriers and elevate educational quality in a meaningful and enduring way.

## Acknowledgments

The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

## Author Contribution

All authors contributed equally to this work.

## Funding

This research has no funding source.

## Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

## Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

# References


[1] J. Hattie, "Visible Learning: TO Synthesis of Over 800 Meta-Analyses Relating to Achievement," Routledge , 2009.
[2] M. Fullan , "Leading in to Culture of Change," Jossey -Bass, 2001.
[3] P. W. Jordan, "Improving Education Quality through to Systematic Approach," Journal of Educational Research, vol. 90, no. 1, pp. 24-30, 1996.
[4] DJ Choy and RJR Cole, "Assessing the Impact of Quality Education Initiatives," Education Policy Analysis Archives, vol. 15, no. 10, pp. 1-22, 2007.
[5] AND. M. Rogers, "Diffusion of Innovations," 5th ed., Free Press, 2003.
[6] CHD Anderson and DR Smith, "Evaluating Educational Quality: Methods and Metrics," Educational Evaluation and Policy Analysis, Vol. 21, no. 4, pp. 335-348, 1999.
[7] TP Smith and MM Jones, "Measuring the Quality of Education: TO Review of Methodologies," International Journal of Educational Research, Vol . 48, no. 2, pp. 120-134, 2008.
[8] ALD Haynes and LB Miller, "Educational Quality Improvement: Strategies and Results," Quality Assurance in Education, Vol. 15, no. 3, pp. 256-269, 2007.
[9] KL Wilson and HW Pearson, "Challenges in Enhancing Quality in Education Systems," Educational Policy Review, vol. 12, no. 1, pp. 45-62, 2010.
[10] Smarandache, F. (2022). Neutrosophic statistics es an extension of interval statistics, while Plithogenic statistics - tics es the most general form of statistics (second version). Magazine International Neutrosophic Sciences (IJNS), 19, 148-165.
[11] Smarandache, F. (2022). Neutrosophic statistics es an extension of interval statistics, while Plithogenic statistics - tics es the most general form of statistics (third version). Science Bulletin Puree and Applied Mathematics and Statistics, 41, 172-183.
[12] Smarandache, F. (2021). Plithogenic probability and statistics are generalizations of multivariate probability and statistics. Neutrosophic sets and systems, 4 3, 2 80-2 89.
[13] Smarandache, F. (2022). Plithogeny, Plithogenic set, logic, probability and statistics: to brief review. Journal of Computational and Cognitive Engineering, 1, 47-50.
[14] Priyadharshini, SP & Irudayam, FN (2023). An analysis of obesity in schoolchildren during the COVID- 19 pandemic using single-valued Plithogenic fuzzy sets. Neutrosophic systems with applications, 9, 24-28.
[15] Singh, P. K. (2021). Plithogenic Set for Multivariate Data Analysis. International Journal of Neutrosophic Sciences, 1(2), 81-89.
[16] J. Hattie, "Visible Learning: TO Synthesis of Over 800 Meta-Analyses Relating to Achievement," Routledge, 2009.
[17] M. Fullan , "Leading in to Culture of Change," Jossey -Bass, 2001.
[18] Smarandache, F. (2022). Neutrosophic statistics es an extension of interval statistics, while Plithogenic statistics - tics es the most general form of statistics (second version). Magazine International Neutrosophic Sciences (IJNS), 19, 148-165.
[19] Smarandache, F. (2022). Neutrosophic statistics es an extension of interval statistics, while Plithogenic statistics - tics es the most general form of statistics (third version). Science Bulletin Puree and Applied Mathematics and Statistics, 41, 172-183.
[20] Smarandache, F. (2021). Plithogenic probability and statistics are generalizations of multivariate probability and statistics. Neutrosophic sets and systems, 4 3, 2 80-2 89.
[21] Singh, P. K. (2021). Dark Data Analysis Using Intuitionistic Plithogenic Graphs. International Journal of Neutrosophic Sciences, 16(2), 80-100.
[22] Sánchez, FC, Blacio, JHA, Bracho, MGF, Santamaría, DRA and Casanova, RS (2021). Neutrosophic and p Plithogenic statistical analysis in educational development. Neutrosophic Sets and Systems, 44, 223-234.
[23] Martín, N., Smarandache, F. and Broumi , S. (2021). Covid-19 Decision Making Model Using Extended Plithogenic Hypersoft Sets with Dual Dominant Attributes. International Journal of Neutrosophic Science, 13 (2), 75-86.
[24] Smarandache, F. (2023). An overview of the Plithogenic set and symbolic Plithogenic algebraic structures. Journal of Extension and Fuzzy Applications, 4, 48-55.
[25] Dey , S., & Ray, G. C. (2023). Properties of Redefined Neutrosophic Composite Relation. *Neutrosophic Systems With Applications*, *7* , 1-12. https://doi.org/10.61356/j.nswa.2023.27
[26] Pandiselvi , M., & Jeyaraman , M. (2024). Fixed Point Results in Complex Valued Neutrosophic b-Metric Spaces with Application. *Neutrosophic Systems With Applications*, *17*, 21-33. https://doi.org/10.61356/j.nswa.2024.17244
[27] Mohamed, Z., M. Ismail, M. and Abd El- Gawad , A. (2023) " Sustainable Supplier Selection using Neu - trosophic Multi-Criteria Decision Making Methodology ", *Sustainable Machine Intelligence Journal* , 3,pp. (2):1–9. doi:10.61185/ SMIJ.2023.33102
[28] He- Douh , TO. (2023) " TO Neutrosophic Multi-Criteria Model for Evaluating Sustainable Soil Enhancement Methods and their Cost Implications in Construction", *Sustainable Machine Intelligence Journal* , 5, pp. (1):1–11. doi:10.61185/ SMIJ.2023.55101