Neutrosophic Computing and Machine Learning, Vol. 33, 2024

University of New Mexico

Estudio del impacto adverso de las barreras al aprendizaje en la calidad de la educación mediante el análisis de estadísticas plitogénicas.

Study of the adverse impact of learning barriers on the quality of education through the analysis of plitogenic statistics.

Pedro Fernando Mite Reyes[1], and Carlos Fernando Morales Vera[2]

[1] Ministry of Education, Ecuador. E-mail: pedro.mite@educacion.gob.ec
[2] Ministry of Education, Ecuador. E-mail: fernando.morales@educacion.gob.ec

Resumen. En el ámbito educativo, el estudio de las barreras de aprendizaje y su impacto en la calidad de la educación es un tema de creciente interés, especialmente cuando se aborda a través de la estadística plitogénica. Este enfoque innovador desentraña patrones complejos que tradicionalmente han pasado desapercibidos, revelando cómo las diversas dificultades de aprendizaje no sólo afectan al rendimiento académico individual, sino que también tienen repercusiones a largo plazo en la cohesión social y el desarrollo económico. Plitogenic, con su capacidad para analizar datos multifactoriales, proporciona una visión profunda y matizada de la dinámica educativa, poniendo de relieve las interacciones entre factores como el entorno socioeconómico, las infraestructuras escolares y las políticas educativas. Al considerar la influencia de estas barreras, se hace evidente que la educación no es un fenómeno aislado, sino más bien un sistema interconectado en el que cada obstáculo puede generar un efecto dominó, amplificando las desigualdades existentes. Las estadísticas plitogénicas, al ofrecer una perspectiva holística, subrayan la necesidad de enfoques integrales para abordar las barreras al aprendizaje. Esto implica no sólo intervenciones directas en el aula, sino también reformas estructurales que tengan en cuenta las particularidades culturales y regionales. En definitiva, este análisis pretende no sólo mejorar la calidad de la educación, sino también fomentar una mayor equidad y justicia social, garantizando que todos los estudiantes tengan la oportunidad de alcanzar su pleno potencial.

Palabras clave: Barreras de Aprendizaje, Probabilidad Plitogénica, Estadística Plitogénica, Estadística Multivariante, Plitogénica, Número Neutrosófico.

Abstract. In the educational field, the study of learning barriers and their impact on the quality of education is a topic of growing interest, especially when approached through plitogenic statistics. This innovative approach unravels complex patterns that have traditionally gone unnoticed, revealing how various learning difficulties not only affect individual academic performance, but also have long-term repercussions on social cohesion and economic development. Plitogenic, with its ability to analyze multifactorial data, provides a deep and nuanced view of educational dynamics, highlighting the interactions between factors such as the socioeconomic environment, school infrastructure and educational policies. When considering the influence of these barriers, it becomes evident that education is not an isolated phenomenon, but rather an interconnected system where each obstacle can generate a domino effect, amplifying existing inequalities. Plitogenic statistics, by offering a holistic perspective, underscore the need for comprehensive approaches to address learning barriers. This implies not only direct interventions in the classroom, but also structural reforms that consider cultural and regional particularities. Ultimately, this analysis seeks not only to improve educational quality, but also to foster greater equity and social justice, ensuring that every student has the opportunity to reach their full potential.

Keywords: Learning Barriers, Plitogenic Probability, Plitogenic Statistics, Multivariate Statistics, Plitogenic, Neutrosophic Number.

1 Introduction

Education is a fundamental pillar in the development of any society, and its quality directly influences the economic, social and cultural progress of nations. However, there are various learning barriers that can negatively affect

educational quality, limiting students' potential and perpetuating inequalities [1]. These barriers, ranging from socioeconomic issues to deficiencies in educational infrastructure, represent a complex and multifaceted challenge that requires urgent and strategic attention. Learning barriers are not isolated phenomena, but are often interrelated, creating a network of obstacles that can be difficult to overcome. For example, a lack of educational resources may be linked to unfavorable family environments, which in turn affect students' motivation and academic performance. These types of interdependencies underscore the need for a comprehensive and multidimensional approach to addressing learning barriers [2].

A critical aspect to consider is the diversity of factors that influence learning. Factors such as poverty, domestic violence, malnutrition, and limited access to information technologies, among others, can have a significant impact on students' ability to learn. These factors not only affect academic performance, but can also influence students' self-esteem and mental health, creating a cycle of disadvantage that is difficult to break. Detailed analysis of learning barriers makes it possible to identify patterns and trends that may not be evident to the naked eye. This analysis is crucial to designing effective interventions that address the specific needs of students [3]. For example, recent research has shown that psychoeducational support programs and family interventions can have a significant positive impact on overcoming certain learning barriers. Furthermore, the implementation of inclusive educational policies is essential to ensure that all students have access to quality education. This involves not only the improvement of school infrastructure and the provision of adequate educational resources, but also the creation of a learning environment that is sensitive to the needs of students. Inclusive policies must consider cultural and linguistic diversity, as well as the different abilities and learning styles of students.

The role of educators is fundamental in this context. Teachers must not only be trained to identify and address learning barriers, but they must also be supported to implement effective educational strategies [4]. Continuing training and professional development for teachers are key aspects of improving the quality of education and ensuring that students receive the support they need. Community involvement is another crucial factor in overcoming learning barriers. Schools must work collaboratively with families, community organizations and local authorities to create a supportive environment that promotes the learning and holistic development of students. This collaboration may include mentoring programs, extracurricular activities, and social and emotional support services.

Technology also plays an important role in modern education. Access to information and communication technologies can open new learning opportunities and help overcome some learning barriers. However, it is important to ensure that all students have access to these technologies and know how to use them effectively [5]. The digital divide remains a significant barrier in many communities, and must be addressed to ensure equitable education. Finally, it is crucial to continually evaluate the impact of educational interventions and adjust strategies as necessary. Research and data analysis should be integral components of the educational process, allowing for dynamic adaptation to the changing needs of students and communities. Through an evidence-based approach, it is possible to identify best practices and replicate them in different contexts. In summary, the study of the adverse impact of learning barriers on the quality of education is essential to design and implement effective strategies that promote equitable and high-quality education. Addressing these barriers requires a comprehensive approach that considers the diversity of interrelated factors that affect learning, as well as collaboration between educators, families, communities, and education policy makers. Only through a concerted and sustained effort can we ensure that all students have the opportunity to reach their full potential.

2 Related Words.

2.1. Learning Barriers.

Learning barriers are one of the main challenges facing the contemporary education system. These barriers can take multiple forms, from cognitive and emotional difficulties to economic and social obstacles. Identifying and overcoming these barriers is crucial to ensuring that all students have the opportunity to reach their full potential. In this context, it is essential to understand the nature of these barriers and develop effective strategies to mitigate them [6]. First of all, it is important to recognize that learning barriers are not homogeneous. Some are intrinsic to the individual, such as attention difficulties, dyslexia or autism spectrum disorders. These barriers require specific interventions and curricular adaptations so that students can fully participate in the educational process. On the other hand, there are extrinsic barriers, such as lack of educational resources, unfavorable socioeconomic environment and insufficient family support. These external barriers must also be addressed through inclusive educational policies and greater investment in resources. Overcoming learning barriers requires a holistic approach that considers all dimensions of the problem. It is not enough to focus efforts in the classroom; It is necessary to involve the community, families and those responsible for educational policies. Collaboration between these actors is essential to create a comprehensive supportive environment that fosters student learning and development [7]. This includes the implementation of mentoring programs, extracurricular activities, and emotional and psychological support services.

A crucial aspect in the fight against learning barriers is the continuous training of teachers. Educators must be prepared to identify and address the various difficulties that students may face. This involves not only the acquisition of specific knowledge and skills, but also the development of an empathetic and understanding attitude. Teachers

must be able to adapt their teaching methods to the individual needs of students, creating an inclusive and stimulating environment. Technology can play a significant role in overcoming learning barriers. Digital tools and online learning platforms offer new opportunities to personalize education and provide additional support to struggling students . However, it is crucial to ensure that all students have access to these technologies and know how to use them effectively. The digital divide remains a significant barrier, especially in disadvantaged communities, and must be addressed to ensure equitable education [8].

Evaluating the impact of educational interventions is essential to identify the most effective strategies and replicate them in different contexts. Research and data analysis should be integral components of the educational process, allowing for dynamic adaptation to the changing needs of students. Evidence-based policies are critical to designing and implementing educational programs that truly make a difference. Furthermore, it is vital to consider the influence of socioeconomic factors on learning barriers. Poverty, lack of access to basic services, and food insecurity are significant barriers that can affect students' academic performance. Addressing these issues requires a comprehensive approach that goes beyond the educational field, including social and economic policies that improve the living conditions of families. Community participation in education is another key element in overcoming learning barriers . Schools must work closely with families and community organizations to create a supportive environment that promotes comprehensive student learning and development. This includes participation in school activities, volunteer programs, and building community support networks [9].

Finally, it is essential to promote a culture of inclusion and respect in the educational field. All students, regardless of ability or background, should feel valued and supported. This involves not only the implementation of inclusive policies, but also the promotion of positive attitudes towards diversity and difference. Inclusive education is not only a matter of social justice, but also an effective strategy to improve educational outcomes and build more equitable and cohesive societies. Learning barriers are a complex and multifaceted challenge that requires a comprehensive and collaborative approach to overcome. It is necessary to consider both intrinsic and extrinsic barriers, involving all actors in the educational process. Continuous teacher training, the use of technology, constant evaluation of interventions and community participation are key elements to create an inclusive and high-quality educational environment. Only through a joint and sustained effort can we ensure that all students have the opportunity to reach their full potential and contribute to the development of more just and equitable societies.

2.2. Plitogenic Statistics (PS).

Plitogenic 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 plitogenic statistics in the study of learning barriers and the quality of education are analyzed and assessed. First, plitogenic statistics allow for the simultaneous analysis of multiple factors that affect learning [10]. 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 [11].

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 plitogenic 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 [12]. 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 plitogenic 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 [13]. 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. Plitogenic 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 plitogenic 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 [14]. This not only improves the quality of education, but also contributes to reducing inequalities and promoting social justice. In conclusion, plitogenic statistics represent 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 Plitogenic Statistics which are shown:
- Multivariate statistics,
- Neutrosophic Plitogenic Statistics,
- Plitogenic indeterminate statistics,
- Plitogenic intuitionistic fuzzy statistics,
- Fuzzy statistics of plitogenic images,
- Plitogenic spherical fuzzy statistics,
- and in general: Plitogenic 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 Equation 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 : ([15-16]) 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 are summarized below ([17]):

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, it 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.

1. 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 Ii = [aiL , aiU]. 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 ^{ith} 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:

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

$D_{ji}$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:

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

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:

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

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.

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

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:

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

equivalently for the control group:

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

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

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

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

While :

$\overline{\widetilde{\Delta}}_j^* = \overline{D}_j^* - \overline{\widetilde{D}}_j^*(10)$

Denotes the difference between the average 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:

Figure 1 shows the percentages achieved in the interval for the **Academic Dimension.**

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

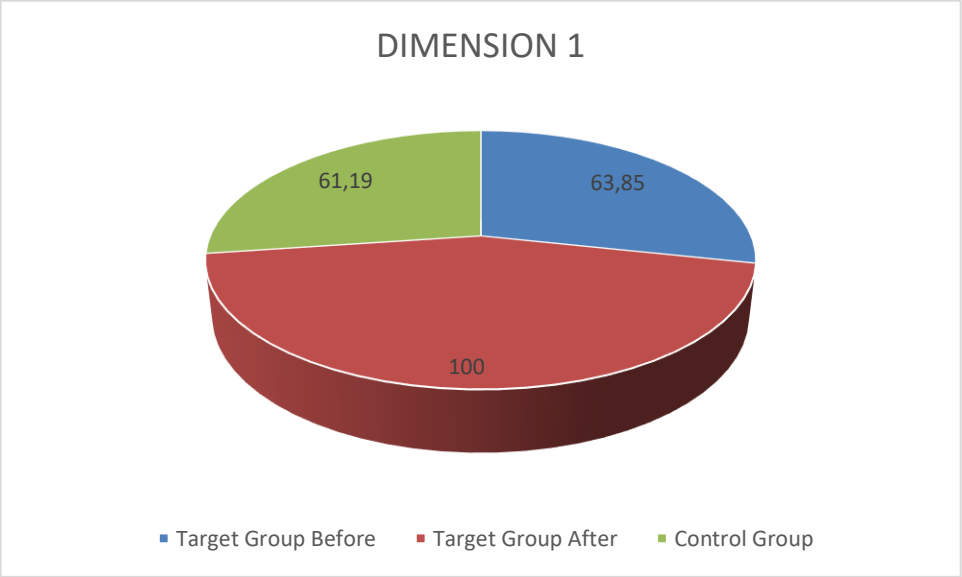


Figure 2 is the result of Dimension "Dimension **of the School Environment** ".

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

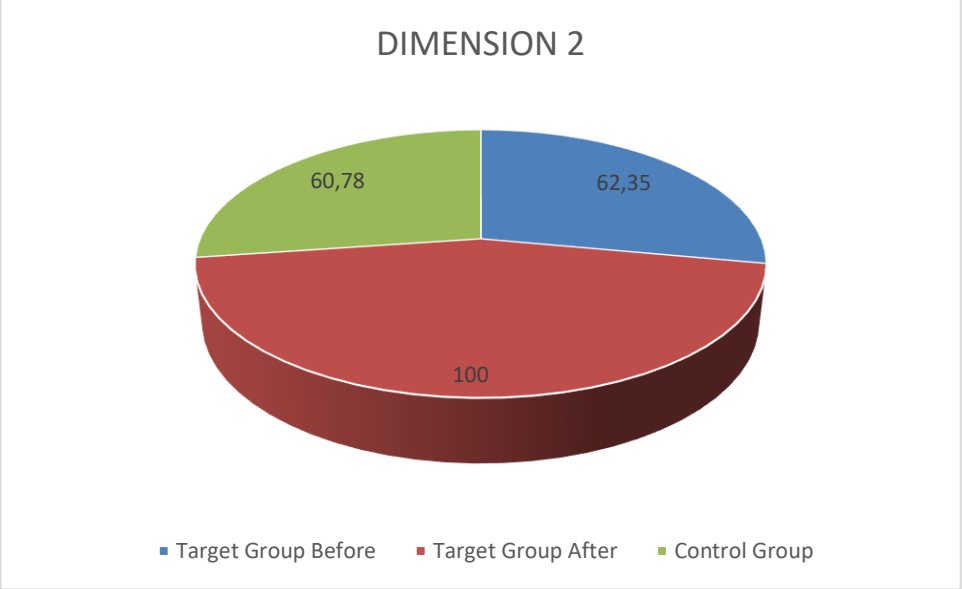


Figure 3 refers to the result of the Dimension: "Dimension **of Comprehensive Student Development"**.

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

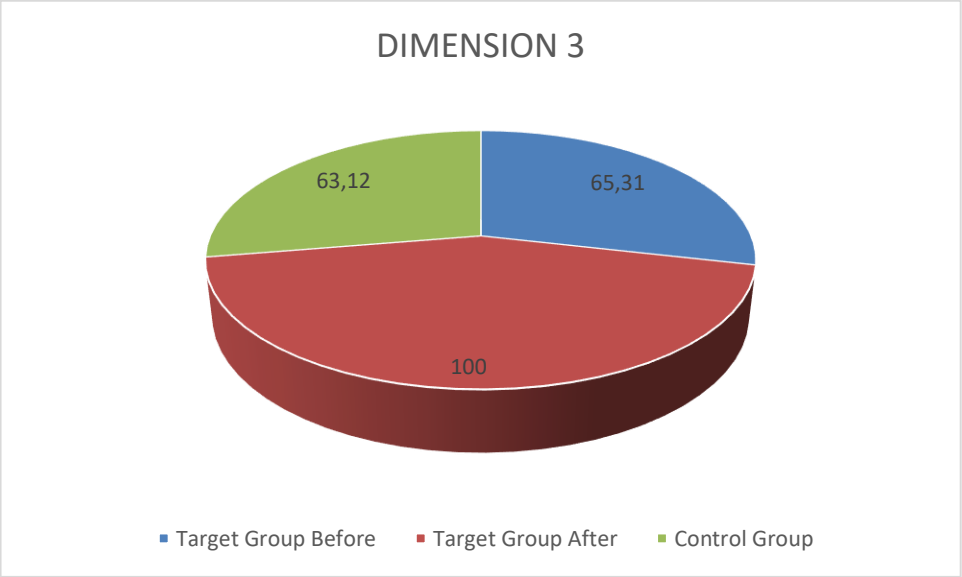
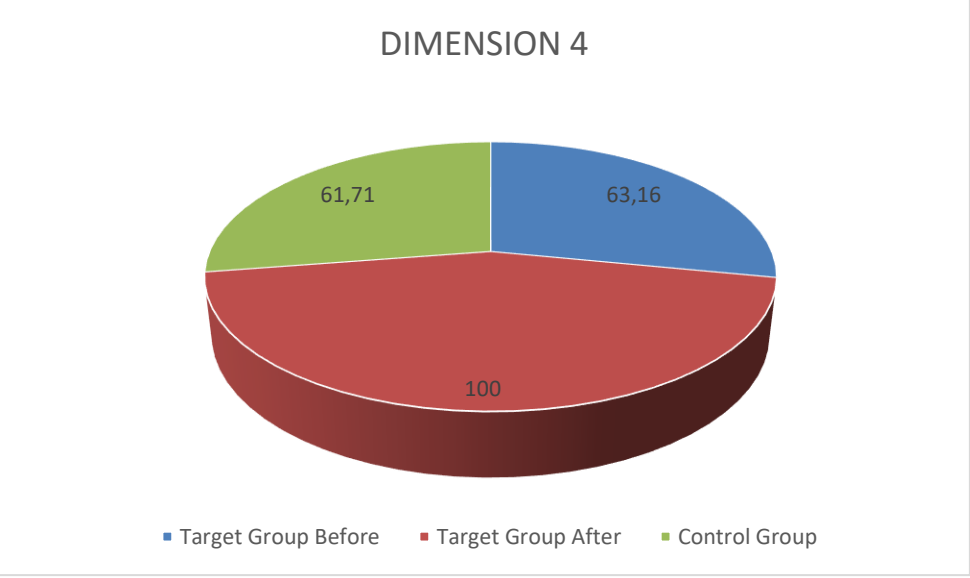


Figure 4 refers to the result of the Dimension: "Participation **and Governance Dimension"**.

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:

- $\overline{\overline{\Delta}}_1^* = [100, 100] - [66.16, 69.71] = [33.84, 30.29]$,
- $\overline{\overline{\Delta}}_2^* = [100, 100] - [63.34, 62.35] = [36.66, 37.65]$,
- $\overline{\overline{\Delta}}_3^* = [100, 100] - [64.33, 61.12] = [35.67, 38.88]$,
- $\overline{\overline{\Delta}}_4^* = [100, 100] - [65.87, 64.19] = [34.13, 35.81]$.

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:

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

In this case,

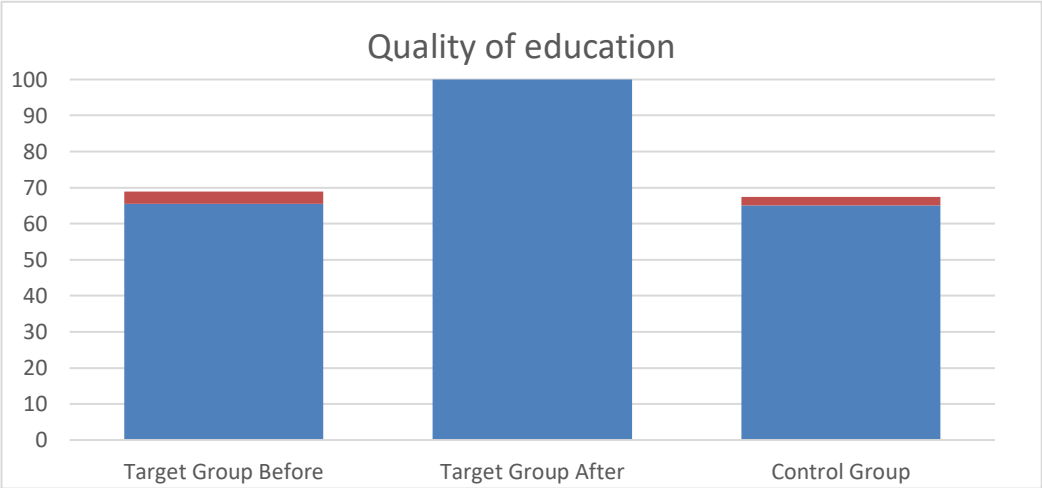
$D^* = \min([63.85, 61.19], [62.35, 60.78], [65.31, 63.12], [63.16, 61.71]) = [62.35, 60.78]$ It is the result of the target group before the educational reforms.

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

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

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.

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

In this case, it is:

$[62.35, 60.78] \ominus [63.34, 61.12] = [1.23, 2.56]$ Which 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 to the difference [1. 23, 2. 56], offers a fascinating insight into the impact of the quality of education in relation to 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.

Conclusion

The analysis of the results obtained in the comparison between [62. 35, 60. 78] and [63. 34, 61. 12], reflected in a difference of [1. 23,2. 56], reveals a slight variation that raises important questions about educational quality in the context of the learning barriers. This difference, although less than 5. 1%, suggests that, despite efforts to improve the quality of education, learning barriers continue to exert a significant influence on educational outcomes. This highlights that current interventions may not be fully effective in addressing these challenges comprehensively. The persistence of learning barriers, despite the measures implemented, highlights the need for a critical evaluation of ongoing strategies. The fact that educational quality has not shown substantial improvement indicates that the solutions applied so far may lack the depth necessary to address the underlying problems. It is essential to question whether the reforms have been adequate or whether, on the contrary, they have remained superficial adjustments that do not address the root of the problem. On the other hand, the result [100,100] ⊖ [100,100] = [0, 0] suggests a high positive correlation between "learning barriers" and "poor quality of education" after the program. This finding suggests that the two variables have evolved in a synchronized manner, which could indicate that the program has achieved alignment in the changes observed in both areas. However, this high correlation does not necessarily guarantee a comprehensive solution to the underlying problems.

The high, positive correlation could reflect an alignment in patterns of change, but this should not be interpreted as irrefutable proof of success in solving the problems. Rather than a qualitative improvement in educational quality, the correlation may suggest that both learning barriers and educational quality have been adjusted in parallel without significant progress in absolute terms. In this sense, it is crucial to consider whether the interventions have been profound enough to cause a significant change in educational quality. Equality in post-program measurements could mask underlying problems that require more specific and detailed attention. The solution provided could be insufficient to address the underlying problems and lastingly improve educational quality. It is recommended to carry out a more comprehensive evaluation of the implemented interventions, with an approach that goes beyond superficial adjustments. Detailed understanding of individual barriers and their specific impacts is critical to designing more effective and targeted strategies. A more nuanced analysis is necessary to identify areas that still require attention and development. In summary, although the analysis reveals some advances, it also highlights important limitations. The slight difference in baseline measurements and the high correlation observed after the program

suggest that, while 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 study highlights the complexity of the path to quality education and the importance of constant and critical attention. The data suggests 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 raised significantly and sustainably.

References

[1] J. Hattie, "Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement," Routledge, 2009.

[2] M. Fullan , "Leading in a Culture of Change," Jossey -Bass, 2001.

[3] P. W. Jordan, "Improving Education Quality through a 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] E. 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: A 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 is an extension of interval statistics, while plitogenic statistics is the most general form of statistics (second version). Magazine International Neutrosophic Sciences (IJNS), 19, 148-165.

[11] Smarandache , F. (2022). Neutrosophic statistics is an extension of interval statistics, while plitogenic statistics is the most general form of statistics (third version). Science Bulletin Pure and Applied-Mathematics and Statistics , 41, 172-183.

[12] Smarandache, F. (2021). Plitogenic probability and statistics are generalizations of multivariate probability and statistics . Neutrosophic sets and systems , 4 3 , 2 80-2 89 .

[13] Smarandache, F. (2022). Plitogeny, Plitogenic set, logic, probability and statistics: a brief review. Journal of Computational and Cognitive Engineering, 1, 47-50.

[14] Priyadharshini , S.P. & Irudayam , F.N. (2023). An analysis of obesity in schoolchildren during the COVID-19 pandemic using single-valued Plitogenic fuzzy sets. Neutrosophic systems with applications, 9, 24-28.

[15] Singh, P. K. (2021). Plitogenic Set for Multivariate Data Analysis . International Journal of Neutrosophic Sciences, 1(2), 81-89.

[16] Singh, P. K. (2021). Dark Data Analysis Using Intuitionistic Plitogenic Graphs. International Journal of Neutrosophic Sciences, 16(2), 80-100.

[17] Sánchez, FC, Blacio, JHA, Bracho, MGF, Santamaría, DRA and Casanova, RS (2021). Neutrosophic and pPlitogenic statistical analysis in educational development. Neutrosophic Sets and Systems, 44, 223-234.

[18] Martín, N., Smarandache, F. and Broumi , S. (2021). Covid-19 Decision Making Model Using Extended Plitogenic Hypersoft Sets with Dual Dominant Attributes. International Journal of Neutrosophic Science, 13 (2), 75-86.

[19] Smarandache, F. (2023). An overview of the Plitogenic set and symbolic plitogenic algebraic structures . Journal of Extension and Fuzzy Applications, 4, 48-55.

[20] 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

[21] 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

[22] Mohamed, Z., M. Ismail, M. and Abd El- Gawad , A. (2023) " **Sustainable Supplier Selection using Neutrosophic Multi-Criteria Decision Making Methodology** ", *Sustainable Machine Intelligence Journal* , 3, pp. (2):1–9. doi:10.61185/SMIJ.2023.33102 .

[23] El- Douh , A. (2023) " **A 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 .

[24] Ranulfo Paiva Barbosa (Sobrinho), & Smarandache , F. (2023). Pura Vida Neutrosophic Algebra. *Neutrosophic Systems With Applications* , *9* , 101-106. https://doi.org/10.61356/j.nswa.2023.68

[25] N. Mostafa , N., Krishan Kumar , A. and Ali, Y. (2024) " **A Comparative Study on X-Ray image Enhancement Based on Neutrosophic Set** ", *Sustainable Machine Intelligence Journal* , 7, pp. (2):1–10. doi:10.61356/SMIJ.2024.77102 .

[26] Christianto , V. and Smarandache , F. (2024) " **The Convergence of Ikigai and Design Thinking: Crafting a Purposeful Framework** ", *Sustainable Machine Intelligence Journal* , 7, pp. (1):1–7. doi:10.61356/SMIJ.2024.77101 .

[27] Smarandache , F. (2023). Introduction and advances to neutrosophic probability and statistics and plitogenic probability and statistics and their applications in bioinformatics and other fields (review chapter). In Cognitive intelligence with neutrosophic statistics in bioinformatics (pp. 1-23). Academic Press.

[28] Martin, N., Smarandache, F., & Sudha , S. (2023). A novel decision-making method based on plitogenic contradictions. Neutrosophic Systems with Applications , 10, 12-24.

[29] Rezaei , A. Oner , T. Katican , T. Smarandache, F. Gandotra , N. (2022). A brief history of fuzzy, intuitionistic, neutrosophic and pPlitogenic sets . Journal of International Journal of Neutrosophic Sciences, 18 (1) , 99-116.

[30] Batista- Hernández, N., Leyva- Vázquez, MY, González- Caballero, E., Valencia- Cruzaty , LE, Ortega-Chávez, W. and Smarandache, F. (2021). A new method to assess entrepreneurial competence in university students using Plitogenic numbers and SWOT analysis. International Journal of Fuzzy Logic and Intelligent Systems, 21, 280-292.

[31] Smarandache, F. (1998) Neutrosophia: probability, set and neutrosophic logic: analytic synthesis & synthetic analysis, technical report.

[32] Jin , L. , Zhang, C. , Wen , 96648.

[33] Moore, R.E. (1966) Interval Analysis, Prentice Hall, Englewood Cliffs.

Recibido: mayo 14, 2024. **Aceptado:** junio 02, 2024