Neutrosophic Sets and Systems {Special Issue: Neutrosophy and Plithogeny: Fundamentals and Applications}, Vol. 69, 2024

University of New Mexico

Exploring the Impact of Educational Reforms and Their Dimensions on Teacher Performance Through the Analysis of Plithogenic Statistics

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Abstract. The exploration of the impact of educational reforms on teacher performance is a topic that has gained unusual relevance in recent decades. By analyzing these reforms through the prism of Plithogenic statistics, a window opens to a new approach that allows us to understand the inherent complexity of contemporary educational systems. Plithogenic statistics, which integrate heterogeneous and multivariate data, provide a powerful tool for unraveling how educational policies affect teacher performance. In this study, a multifaceted approach has been employed, ranging from longitudinal data analysis to qualitative evaluation of teacher perceptions, revealing an intricate interconnection between the reforms implemented and the results observed in the classrooms. The conclusions derived from this analysis are revealing and, in a certain sense, paradigmatic. Educational reforms, far from being mere administrative interventions, emerge as agents of dynamic change that influence the motivation, professional development and, ultimately, the performance of teachers. However, this impact is not homogeneous; varies significantly depending on the institutional context and the individual characteristics of educators. Through the application of Plithogenic methods, it has been possible to capture the subtle interaction of these factors, providing a more nuanced and holistic vision of educational reality. In summary, this study not only expands the understanding of educational reforms, but also highlights the importance of using advanced statistical approaches to capture the complexity of modern educational phenomena.

Keywords: Educational Reforms, Plithogenic Probability, Plithogenic Statistics, Multivariate Statistics, Plithogenicity, Neutrosophic Number .

1. Introduction

Education, a fundamental pillar of social and economic development, has been the subject of various reforms over time. In this context, the evaluation of the impact of these reforms on teaching performance emerges as an issue of increasing importance. Understanding how educational policies affect teachers is not only crucial for improving educational quality, but also for the design of future intervention strategies [1]. This study seeks to explore this relationship through the use of Plithogenic statistics, an innovative and complex approach that allows for a deeper and multidimensional analysis. Plithogenic statistics, at its core, represent a significant methodological advance, combining data of diverse nature to offer a holistic perspective [2]. This approach is not only limited to the quantification of results, but also integrates qualitative and contextual aspects, providing a richer and more nuanced understanding of educational phenomena. By applying this method to the study of educational reforms, the aim is to unravel the multiple layers of influence that they exert on teacher performance [3].

The choice of Plithogenic statistics is based on the need to overcome the limitations of traditional methods, which often oversimplify educational reality. Educational reforms, by their nature, are complex interventions that interact with a host of contextual and personal variables. In this way, a Plithogenic analysis allows us to capture the essence of these interactions, offering a more realistic and detailed vision of the impact of educational policies.

Teaching performance, understood as a multidimensional construct, covers aspects that go beyond the simple academic performance of students [4]. It includes motivation, continuous professional development, job satisfaction and the ability to adapt to new educational paradigms. Therefore, any study that seeks to evaluate the impact of educational reforms must necessarily consider this complexity and diversity of factors. This study focuses on a comprehensive analysis of the educational reforms implemented in recent years, using data collected from various sources. Through a Plithogenic approach, the direct and indirect effects of these reforms on teaching performance will be analyzed, considering variables such as professional training, availability of resources, working conditions

and institutional support. The integration of these elements will allow a more comprehensive and precise evaluation of the observed impacts.

One of the main hypotheses of this study is that educational reforms, although designed to improve the quality of education, can have varied and not always positive effects on teacher performance. The pressure to adapt to new regulations, the lack of adequate resources and increased responsibilities can generate tensions and challenges that negatively affect teachers. However, it is also possible that certain reforms provide tools and support that enhance professional development and teacher effectiveness. The use of Plithogenic statistics in this analysis will not only validate or refute this hypothesis, but will also open new avenues of research. This methodological approach, by considering multiple dimensions and variables, offers the possibility of discovering patterns and correlations that would not be evident through traditional methods. Thus, the findings of this study are expected to contribute significantly to the existing body of knowledge on education and educational reform [5].

Exploring the impact of educational reforms on teacher performance through the analysis of Plithogenic statistics represents an innovative and necessary effort. By adopting this approach, we seek not only to evaluate the effects of current educational policies, but also to provide valuable elements for the design of future reforms. Ultimately, the goal is to improve the quality of education through a deeper and more detailed understanding of the factors that influence teacher performance.

2. Related Words.

2.1 Educational Reforms.

Educational reforms, a recurring phenomenon in the history of education, continually seek to improve the quality of the educational system. Each country, with its unique particularities and contexts, has implemented reforms with varying degrees of success and failure. These reforms are often seen as the magic solution to deep-seated problems, from lack of resources to educational inequality. However, it is crucial to critically analyze and evaluate these reforms, understanding their motivations, implementations and results [6].

One of the main motivations behind educational reforms is the need to adapt to social and economic changes. In a globalized and constantly evolving world, educational systems must prepare students to face challenges that did not even exist a decade ago. The reforms seek, in this sense, to modernize the curriculum, integrate emerging technologies and promote critical skills such as critical thinking and creativity [7]. However, the success of these initiatives depends largely on the institutions' ability to adapt and the resources available for their implementation. The implementation of educational reforms is not without challenges. One of the main problems is resistance to change, both on the part of teachers, students and parents. Teachers, accustomed to certain methods and routines, may feel overwhelmed by the need to adapt to new policies and pedagogical approaches. Furthermore, the lack of adequate training and institutional support can turn these reforms into an additional burden rather than a substantial improvement [8]. On the other hand, students and their families may have difficulties understanding and accepting changes, especially if they affect fundamental aspects such as evaluation and curricular content.

Despite the challenges, it is undeniable that some educational reforms have had a positive impact. For example, the inclusion of emotional education in the curriculum has proven to be beneficial for the comprehensive development of students. Likewise, the promotion of inclusive education has allowed boys and girls with disabilities to have access to quality education, breaking down historical barriers and promoting a more equitable society. These examples show that, when implemented correctly, reforms can contribute significantly to the well-being and development of students. However, not all reforms have been equally successful. Some, driven by political or economic interests, have failed by not considering the realities and needs of the educational context. An example of this is the implementation of standardized assessment policies, which often ignore local particularities and individual differences of students. These policies can create excessive pressure and encourage a mechanistic approach to education, to the detriment of creativity and critical thinking. The key, therefore, lies in designing reforms that are sensitive to specific contexts and that involve all educational actors in their development and implementation.

The participation of the educational community is essential for the success of any reform. Teachers, as the main agents of change, must be included in the process of designing and executing educational policies. Their experience and knowledge of the classroom are invaluable in identifying what changes are necessary and how to implement them effectively. Likewise, students and their families must have a voice in these decisions, ensuring that the reforms respond to their needs and aspirations. Only through a participatory and collaborative approach can resistance be overcome and sustainable educational transformation achieved. The continuous and rigorous evaluation of educational reforms is another crucial aspect. It is not enough to implement changes and wait for results; It is necessary to constantly monitor and analyze the effects of these policies. This involves collecting accurate and relevant data, as well as carrying out longitudinal studies that allow us to understand the long-term impact. Only through constant evaluation can the necessary adjustments be made and ensure that the reforms meet their objectives.

Education reforms are powerful tools for improving education systems, but their success depends on careful planning, inclusive implementation, and continuous evaluation. By critically assessing these reforms, we can learn

from past successes and failures, designing more effective policies adapted to the needs of the educational community. Ultimately, the goal must always be to provide quality education for all, preparing them for the challenges of the future and promoting a more just and equitable society.

2.2 Plithogenic Statistics.

Plithogenic statistics (PS) represent an advanced and multifaceted methodological approach in data analysis, designed to handle and synthesize heterogeneous information from multiple sources. Unlike traditional statistical methods, which usually focus on isolated variables or simplified models, PS seeks to capture the complexity and interconnectivity of the phenomena studied. This approach allows for a deeper and more nuanced understanding of the data, offering a powerful tool for research in fields as diverse as education, economics, biomedicine, and more [10].

In the educational field, PS are particularly useful for evaluating the impact of educational reforms. The reforms, by their nature, affect a wide range of factors, from the academic performance of students to the motivation and professional development of teachers. By employing PS, researchers can analyze how these variables interact with each other and influence educational outcomes. This analysis can reveal patterns and correlations that would not be evident through traditional methods, providing valuable elements for the design and implementation of educational policies [11]. The analysis process with PS involves the integration of quantitative and qualitative data, allowing for a more holistic evaluation of the phenomena studied. For example, when evaluating educational reform, quantitative data such as standardized test scores and graduation rates can be considered, along with qualitative data such as teacher perceptions and student experiences. This combination of data provides a more complete and accurate picture of the impact of the reform, helping to identify both its strengths and weaknesses [12].

One of the key advantages of PS is its ability to handle large volumes of data and to identify complex relationships between variables. This is especially important in the context of educational reforms, where the effects can be multidimensional and often non-linear. For example, a reform that improves the resources available to teachers may have direct positive effects on students' academic performance, but may also indirectly influence teachers' motivation and job satisfaction, which in turn affects their effectiveness. in the classroom [13]. PSs allow these complex dynamics to be captured and provide a more detailed understanding of the underlying mechanisms.

The application of PS in educational research also offers opportunities for personalization and adaptation of educational policies. By identifying specific patterns and correlations at the subgroup level, PSs can help design more effective interventions tailored to the particular needs of different school communities. This is crucial in diverse educational contexts, where a policy that works well in one setting may not be equally effective in another [14]. Despite its numerous advantages, PS implementation also presents challenges. Requires a high level of technical competence and a deep understanding of advanced statistical methodologies. Additionally, collecting and integrating heterogeneous data can be complex and costly. However, the potential benefits of a more complete and nuanced understanding of educational phenomena justify these challenges, and investment in PS can pay significant dividends in terms of improving educational quality.

Plithogenic statistics offer a powerful and sophisticated approach to data analysis, allowing for deeper and more detailed evaluation of educational phenomena. By capturing the complexity and interconnectivity of the variables involved, SPs provide valuable elements for the design and implementation of effective educational policies. Despite the challenges associated with their implementation, PS represent an invaluable tool for researchers and policy makers in their efforts to improve the quality of education.

Plithogenic Statistics (PS) comprises the analysis and observations of the events under study. This allows an analysis of many output variables that are neutrosophic or indeterminate.

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 Equation 1[15-16]

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

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 : ([17-18]) 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).

3 Results and Discussion.

The research focused on a population of 339 teachers. 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 25 items. It was administered to both the control and experimental groups, before and after the interventions. The questionnaire was structured as follows:

1. **Quality of Learning (7):**
   - Effectiveness of the teaching methods introduced by the reform.
   - Impact of the reform on the academic performance of students.
   - Teachers' perception of the improvement in students' critical and creative skills.
   - Availability and quality of the educational resources provided.

2. **Teacher Professional Development (7):**
   - Effectiveness of the teacher education and training programs included in the reform.
   - Level of institutional and administrative support received by teachers.
   - Teachers' perception of their professional growth and development opportunities.
   - Teacher satisfaction with new educational methodologies and technologies.

3. **Inclusion and Equity (4):**
   - Impact of the reform on the inclusion of students with special needs.
   - Perception of equity in access to educational resources for all students.
   - Measures taken to reduce achievement gaps between different demographic groups.
   - Evaluation of cultural diversity and curricular adaptation to local realities.

4. **Community Participation and Commitment (7):**
   - Level of involvement of parents and the community in the implementation of the reform.
   - Students' perception of their participation in the educational process and decision making.
   - Effectiveness of communication channels between the school and the community.
   - General satisfaction of the different educational actors (teachers, students, parents) with the reform and its impact on school life.

The years of experience of the teachers and, consequently, the possible limitations they could have in understanding neutrosophic methods were considered. For this reason, they were asked to express their opinions

using a range of values rather than assigning a single value on a continuous numerical scale ranging from 0 (Never) to 10 (Always). These intervals are expressed in the form $I_i = [a_i L, a_i U]$ for each of the respondents.

The validation of the instruments for data collection was carried out through the judgment of experts with a doctorate degree. The reliability of the instruments was evaluated through Cronbach's Alpha analysis. Finally, the results indicated that the instrument used is reliable.

The last step was to administer the survey to the members of the experimental group. All this data was collected to be processed by the researchers. The steps followed are detailed below:

1. Different variables are specified. for the dimensions to measure:
$S = \{s_1, s_2, \ldots, s_{34}\}$denotes the set of students in the study group.
$\tilde{S} = \{\tilde{s}_1, \tilde{s}_2, \ldots, \tilde{s}_{34}\}$denotes the set of students 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 dimension " **Quality of Learning** ",
d_2: Symbolizes the dimension " **Teacher Professional Development** ",
d_3: Symbolizes the dimension " **Inclusion and Equity** ",
d_4: Symbolizes the dimension " **Community Participation and Commitment** ".
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:

$I_{ij}^K = \left[a_{ij}^{KL}, a_{ij}^{KU}\right]$, which is the evaluation of the ith teacher in the objective group for the k th article of the j th dimension.

The equivalent notation for the control group is $\tilde{I}_{ij}{}^K = \left[\tilde{a}_{ij}^{KL}, \tilde{a}_{ij}^{KU}\right]$.

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

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

$D_{ji}$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:

$$\widetilde{D}_{ji} = \sum_{k=1} \tilde{I}_{ij}{}^K \quad (4)$$

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:

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

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.

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

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.

$\overline{D}_j^*$de notes the average of the results for the jth 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:

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

Where $\overline{D}_j^{*after}$ denotes the scores of the study group after passing the program, while $\overline{D}_j^{*before}$ are the previous results.

While :

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

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 **Quality of Learning dimension** .

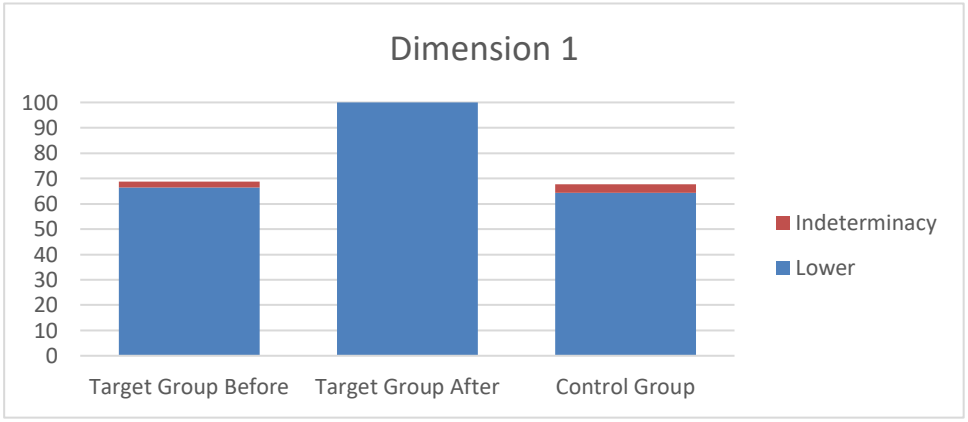

Figure 1. Results of the average of the target group before and after the educational reforms and of the control group for Dimension 1. In blue is the certain percentage and in red is the indeterminate percentage.

Figure 2 is the result of the " **Teacher Professional Development** " Dimension.

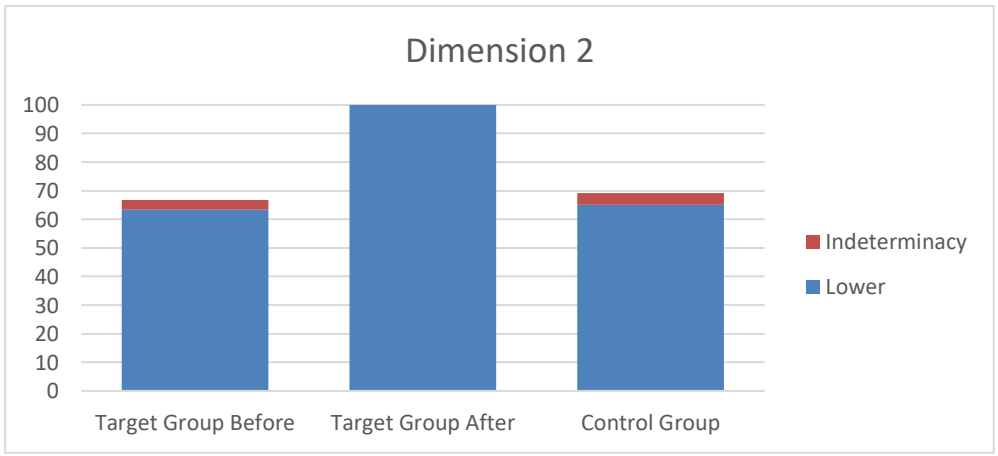

Figure 2. Results of the average of the target group before and after the educational reforms and of the control group for Dimension 2. In blue is the certain percentage and in red is the indeterminate percentage.

Figure 3 refers to the result of the Dimension: "Inclusion and Equity".

Figure 3. Results of the average of the target group before and after the educational reforms and of the control group for Dimension 3. In blue is the certain percentage and in red is the indeterminate percentage.

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

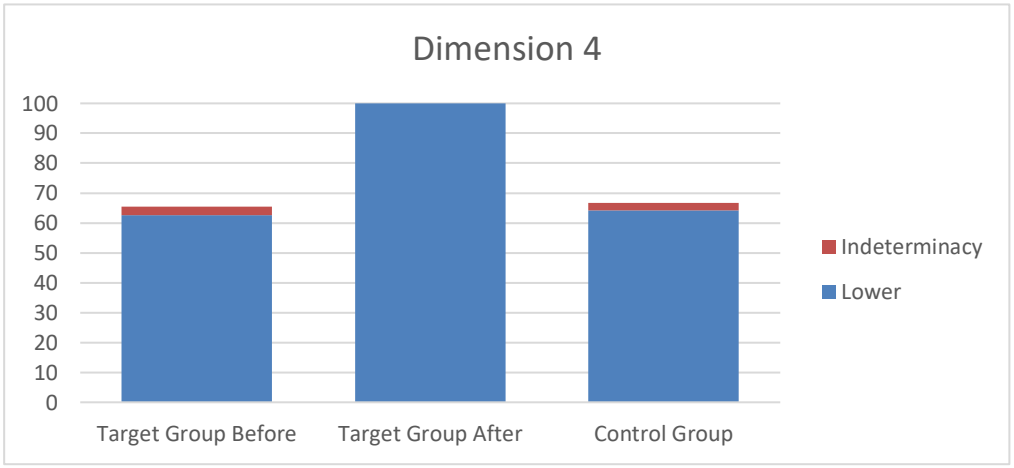

Figure 4. Results of the average of the target group before and after the educational reforms and of the control group for Dimension 4. In blue is the certain percentage and in red is the indeterminate percentage.

Thus using the difference between intervals we have:

- $\overline{\Delta}_1^* = [100,100] - [69\,.31, 62\,.36] = [30\,.69, 37\,.64]$,
- $\overline{\Delta}_2^* = [100,100] - [63\,.36, 62\,.74] = [36\,.64, 37\,.26]$,
- $\overline{\Delta}_3^* = [100,100] - [65\,.21, 72\,.23] = [34\,.79, 27\,.77]$,
- $\overline{\Delta}_4^* = [100,100] - [60\,.96, 62\,.39] = [39\,.04, 37\,.61]$.

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

- $\overline{\overline{\Delta}}_1^* = [100,100] - [62\,.16, 69\,.71] = [37\,.84, 30\,.29]$,
- $\overline{\overline{\Delta}}_2^* = [100,100] - [62\,.34, 66\,.35] = [37\,.66, 33\,.65]$,
- $\overline{\overline{\Delta}}_3^* = [100,100] - [66\,.31, 65\,.12] = [33\,.69, 34\,.88]$,
- $\overline{\overline{\Delta}}_4^* = [100,100] - [62\,.47, 61\,.14] = [37\,.53, 38\,.86]$.

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,

$D^* = \min([69.31, 62.36], [63.36, 62.74], [65.21, 72.23], [60.96, 62.39]) = [60.96, 62.36]$ It is the result of the target group before the educational reforms.

After passing the educational reforms the general result is $[100, 100]$. For the control group this is

$\tilde{D}^* = \min([62.16, 69.71], [62.34, 66.35], [66.31, 65.12], [62.47, 61.14]) = [62.16, 61.14]$.

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

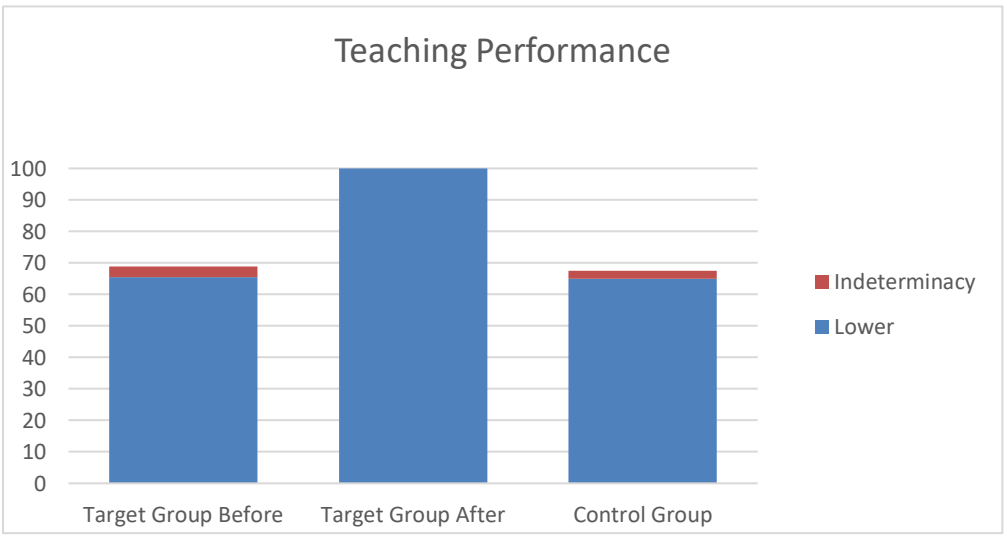

Figure 5. Average results of the target group before and after the educational reforms and of the control group for " teaching performance ". in blue is the certain percentage and in red is the indeterminate percentage.

In this case, we will calculate the difference in absolute value to avoid negative numbers in the calculation of the relationship between educational reforms and teacher performance. 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:

$[62.16, 61.14] \ominus [60.96, 62.36] = [0.2, 0.18]$ which is the result of comparing " teaching performance " with the aggregation of the four dimensions that represent " educational reforms . " This represents a difference of less than 4% 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 " educational reforms " and " teacher performance

4. Conclusion

The conclusions derived from our study on the comparison between "teaching performance" and the aggregation of the four dimensions that represent "educational reforms" reveal significant findings. We find that the result of this comparison, [62. 16, 61. 14] ⊖ [60. 96, 62. 36] = [0. 2, 0. 18], indicates a minimum difference of less than 4%. This finding suggests a close relationship between the reforms implemented and the impact on teacher performance. On the other hand, when analyzing [100, 100] ⊖ [100, 100] for both variables after the program, we observe a result of [0, 0]. This situation denotes a high and positive correlation between educational reforms and teaching performance, where both maintain consistent and positive values after the implementation of the program.

This study highlights the importance of educational reforms as potential catalysts for improving teacher performance. The results show that the dimensions incorporated in the reforms, such as quality of learning, teacher professional development, inclusion and equity, as well as community participation, have a measurable positive impact

on educational outcomes. Furthermore, the relevance of evaluating educational interventions using robust quantitative methods such as those used in this study is highlighted. The use of equations such as equation 12, which calculates differences in absolute value to avoid negative numbers in the relationships between variables, provides an accurate and nuanced measure of the impact of educational policies. The practical implications of these findings are substantial for educational policy makers. We suggest that future research delve into the longitudinal evaluation of educational reforms, considering not only the short-term results but also their sustainability and long-term effects on the educational system. In terms of practical recommendations, it is suggested that policymakers strengthen support and ongoing training for teachers, thereby ensuring that educational reforms are implemented effectively and sustainably. This could include robust professional development programs and the integration of innovative educational technologies that support teaching and learning.

In conclusion, this study provides a deeper understanding of how educational reforms impact teacher performance, highlighting both their achievements and potential areas for further improvement. It is essential to continue researching and refining our educational policies to promote an educational environment that is equitable, inclusive, and that maximizes the potential of all students and educators.

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Received: February 24, 2024. **Accepted:** June 16, 2024