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Data-driven improvement of mathematics competencies in post-pandemic Colombia: Evidence from SABER 11 results and stakeholder perceptions (2021-2024)

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Abstract

The study investigates how data management practices can support the improvement of mathematics competencies among Colombian secondary students in the post pandemic period, focusing on evidence from SABER 11 examinations between 2021 and 2024. Using a qualitative, descriptive–interpretive design, the research combines open ended surveys with documentary analysis of official ICFES reports to identify trends, achievement gaps, influencing factors, and learning difficulties in mathematics across 18 urban and rural schools from multiple regions. The sample includes 1,125 participants (students in grades 10 and 11, university students, and mathematics teachers), allowing triangulation of perceptions with standardized test results. Data were organized through iterative categorization of responses and scores into thematic clusters related to performance levels, socio economic conditions, access to digital resources, and pedagogical practices. Results reveal persistent and, in some cases, widening gaps in mathematical performance between rural and urban schools, as well as between students from different socio economic strata, exacerbated by unequal connectivity, limited family support, and heterogeneous institutional responses during remote learning. Teachers and students report difficulties in consolidating fundamental concepts, problem solving skills, and mathematical reasoning, which align with patterns observed in SABER 11 achievement distributions. The study concludes that systematic use of assessment data, combined with context sensitive qualitative evidence, is essential to inform pedagogical and policy decisions aimed at reducing learning gaps, strengthening data literacy among school leaders and teachers, and designing targeted interventions to enhance mathematics achievement in post pandemic Colombia.

Keywords: Mathematics competencies; Data-driven decision making; Educational assessment; learning gaps; post-pandemic education.

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1. Introduction

COVID-19 pandemic generated unprecedented disruptions to educational systems worldwide, with Latin American countries experiencing some of the longest school closures globally [1]. In Colombia, these interruptions exposed and exacerbated pre-existing structural inequalities within the educational system, particularly affecting the development of mathematics competencies among secondary students [2]. According to recent PISA results, Colombia ranked 64th out of 81 participating countries with a mathematics score of 383 points—significantly below the international average of 438 points [3]. This concerning trajectory demands urgent investigation into how data management practices might inform evidence-based interventions to address learning losses and persistent achievement gaps.

Mathematics competencies constitute a fundamental pillar for developing critical and analytical skills essential in today's increasingly demanding labor market [4]. However, the effective management of educational data remains underutilized in Colombian institutions, hindering the identification of student needs and the adaptation of pedagogical practices to changing realities [5]. As Antúnez and Imbernón [6] emphasize, transforming raw data into collective knowledge is crucial for guiding informed decisions in teaching-learning processes. Without efficient data utilization, educational practices fail to adapt to students' evolving needs and the new demands of contemporary learning environments.

This research addresses a critical gap in understanding how systematic analysis of standardized assessment data—particularly from SABER 11 examinations—can inform targeted interventions to improve mathematics education in Colombia's post-pandemic context. The study responds to the urgent need identified by Godino [7] for developing theoretical tools in mathematics education that support the implementation of more appropriate didactic strategies. By examining trends, gaps, factors, and difficulties affecting mathematics performance between 2021 and 2024, this investigation provides actionable insights for teachers, school leaders, and policymakers seeking to transform educational practices toward more equitable, innovative, and transformative approaches.

This study addresses the following research question: How can systematic data management practices support the improvement of mathematics competencies in post-pandemic Colombian secondary education, based on SABER 11 outcomes and stakeholder perceptions between 2021 and 2024? The study aims to a) identify trends and gaps in SABER 11 mathematics performance between 2021 and 2024, b) characterize stakeholder perceptions about post-pandemic mathematics learning difficulties, and c) propose implications for evidence-informed educational improvement.

2. Methods and Methodology

2.1. Research Design and Approach

This study adopted a convergent mixed-methods research design, integrating quantitative and qualitative data to obtain a comprehensive understanding of mathematics competencies in post-pandemic Colombian secondary education. Mixed-methods research enables the combination of numerical trends with participants' experiences and perceptions, providing a richer interpretation of educational phenomena than either approach alone [8].

The quantitative component focused on the analysis of official SABER 11 mathematics examination results from 2021 to 2024, allowing the identification of performance trends, achievement gaps, and variations across educational contexts. The qualitative component explored perceptions of students, university students, and mathematics teachers regarding learning difficulties, influencing factors, and post-pandemic educational challenges through open-ended survey responses.

The convergent design allowed both datasets to be collected and analyzed independently and subsequently integrated during the interpretation stage. This approach facilitated triangulation between standardized assessment outcomes and stakeholder perceptions, strengthening the validity and credibility of the findings.

The study was guided by the following research question:

How can systematic data management practices support the improvement of mathematics competencies in post-pandemic Colombian secondary education, based on SABER 11 outcomes and stakeholder perceptions between 2021 and 2024?

The specific objectives were:

a) To identify trends and achievement gaps in SABER 11 mathematics performance between 2021 and 2024.

b) To characterize stakeholder perceptions regarding mathematics learning difficulties in the post-pandemic context.

c) To derive implications for data-informed educational improvement and decision-making.

2.2. Population and Sample

The research population comprised 1,402 individuals associated with 18 educational institutions across diverse Colombian regions. The final sample included 1,125 participants selected through stratified sampling to ensure representation across geographic, socioeconomic, and institutional contexts:

- 947 secondary education students (grades 10 and 11)
- 150 university students who had previously taken SABER 11 examinations
- 28 mathematics teachers from participating secondary institutions

Institutions were strategically selected from urban and rural contexts across nine Colombian departments: Antioquia, Bolívar, Boyacá, Caquetá, Cundinamarca, Meta, Sucre, and Tolima (see Table 1).

Table 1.
Participating educational institutions and geographic distribution.

Department	Municipality	Participants
Antioquia	Sonsón	35
Antioquia	Carmen de Viboral	75
Bolívar	Magangué	85
Bolívar	Cartagena	33
Boyacá	Muzo	89
Boyacá	Puerto Boyacá	124
Boyacá	San Eduardo	41
Caquetá	Valparaiso	24
Cundinamarca	Bogotá	348
Cundinamarca	Viotá	69
Meta	Puerto Gaitán	62
Sucre	Corozal	20
Tolima	Melgar	120
Total		**1,125**

A total of 1,125 participants from 13 municipalities in 8 departments in Colombia took part.

2.3. Data Collection Instruments and Procedures

Two primary instruments were employed for data collection:

Documentary analysis: Official SABER 11 mathematics results (2021–2024) published by ICFES were systematically analyzed to identify performance trends, distribution across proficiency levels, and patterns of incorrect responses across mathematical competencies.

Open-ended surveys: Three differentiated survey instruments were designed and validated through expert judgment for:

- Secondary students (grades 10–11)
- University students
- Mathematics teachers

Surveys explored four analytical categories: (a) trends in mathematics competency development, (b) achievement gaps, (c) factors influencing academic performance, and (d) learning difficulties. All instruments underwent validation by two external experts with extensive experience in educational research and mathematics education.

2.4. Data Analysis Procedures

Data analysis followed the procedures recommended for mixed-methods research and was conducted in three stages: quantitative analysis, qualitative analysis, and integration of findings.

2.4.1. Quantitative Analysis

Official SABER 11 mathematics results from 2021 to 2024 were analyzed using descriptive statistical techniques. Measures included:

- Means and percentages of mathematics performance.
- Distribution of students across proficiency levels.
- Percentage of incorrect responses by mathematical competency.
- Comparative analysis between participating institutions and national averages.

The statistical analysis enabled the identification of performance trends, achievement gaps, and variations in learning outcomes over time.

2.4.2. Qualitative Analysis

Responses from open-ended surveys administered to secondary students, university students, and mathematics teachers were analyzed through thematic analysis. Following Braun and Clarke [9] framework, the analysis involved:

1. Familiarization with the data.
2. Initial coding of responses.
3. Identification of emerging themes.
4. Review and refinement of categories.
5. Interpretation of patterns and relationships.

The qualitative findings were organized into four analytical categories:

- Trends in mathematics competency development.
- Achievement gaps.
- Factors influencing academic performance.
- Learning difficulties.

Microsoft Excel was used to organize, classify, and manage coded qualitative data.

2.4.3. Integration of Quantitative and Qualitative Findings

After independent analyses, quantitative and qualitative results were integrated through triangulation. Convergences, complementarities, and discrepancies between SABER 11 performance indicators and stakeholder perceptions were examined to develop a comprehensive interpretation of mathematics learning in the post-pandemic context.

The integration process enhanced the credibility of the findings and supported the development of evidence-based recommendations for educational practice, institutional leadership, and policy decision-making.

3. Results

3.1. Trends in Mathematics Performance (2021–2024)

Analysis of SABER 11 mathematics results across participating institutions revealed a pattern of partial recovery followed by stabilization below national averages see Table 2. While national average scores increased from 50% (2021) to 52% (2024), participating institutions improved from 48% to 50% during the same period—consistently performing 2–3 percentage points below the national mean.

Table 2.
Average mathematics scores in SABER 11 examinations (2021–2024): Participating institutions versus national average.

Year	Educational Institution (EI)		Colombia	
	Average IE	Deviation IE	Average Colombia	Deviation Colombia
2021	48 %	9 %	50 %	12 %
2022	47 %	11 %	51 %	12 %
2023	50 %	10 %	51 %	12 %
2024	50 %	11 %	52 %	13 %

Table showing two trend lines: one for participating institutions (48%, 47%, 50%, 50%) and one for national average (50%, 51%, 51%, 52%) across the four years.

In the Table 3 shows that the four performance levels provide a qualitative description of student performance, thereby complementing the average score obtained by educational institutions (IE). They detail the actions a student must take to correctly answer the questions asked in accordance with the competencies assessed in the exam [10].

Table 3.
Distribution of students across SABER 11 mathematics proficiency levels (2021–2024).

Year	Performance Level Educational Institutions				Performance Level Colombia			
	1	2	3	4	1	2	3	4
2021	13%	47%	38%	2%	13%	39%	43%	5%
2022	12%	36%	48%	3%	13%	36%	46%	6%
2023	11%	41%	45%	3%	12%	36%	45%	7%
2024	11%	40%	46%	3%	12%	34%	46%	8%

The Table 3 shows modest improvements in Level 3 performance (medium-high) but persistent challenges in achieving excellence (Level 4). While the percentage of students at Level 1 (insufficient) decreased slightly (13% to 11%), the proportion reaching Level 4 remained critically low (2% to 3%) compared to the national average (5% to 8%).

Analysis of incorrect responses across mathematical competencies as shown in the Figure 1 revealed persistent difficulties in higher-order thinking skills. Figure showing three trend lines representing: (1) Strategy formulation and implementation, (2) Procedure validation, and (3) Information transformation across the four years

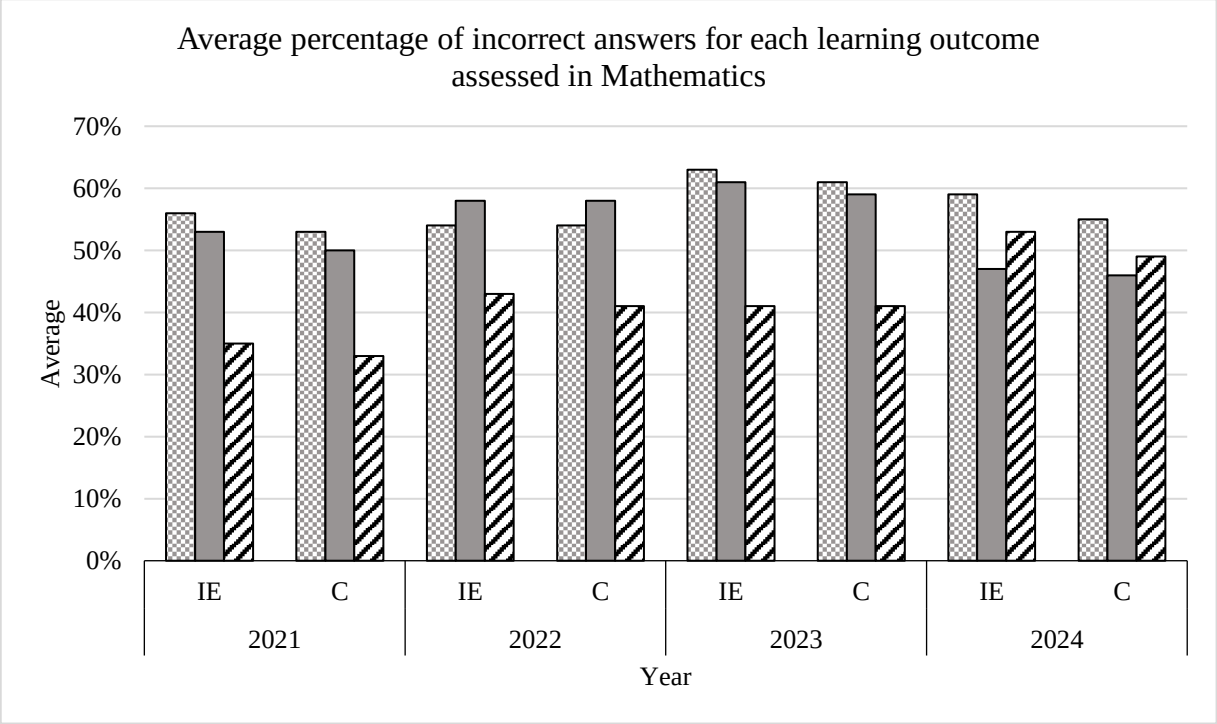

Figure 1.
Percentage of incorrect responses across mathematical competencies (2021–2024).

The percentage of incorrect responses for "formulating and implementing strategies to solve quantitative problems" increased from 56% (2021) to 63% (2023) before decreasing to 59% (2024), while errors in "validating mathematical procedures" showed significant volatility (53% in 2021, 61% in 2023, 47% in 2024)

3.2. Identified Achievement Gaps

Multiple dimensions of achievement gaps emerged from the analysis:

Conceptual gaps: Students demonstrated significant difficulties with fundamental mathematical concepts:

- 20% struggled with trigonometric functions (limiting their ability to interpret periodic phenomena)
- 17% showed deficiencies in algebraic functions (affecting symbolic manipulation and problem-solving)
- 8% had difficulties interpreting graphical representations

Socioeconomic gaps: Survey responses revealed strong correlations between socioeconomic status and mathematics performance:

- 89% of teachers identified socioeconomic stratum as a defining factor in student performance
- 31% of students reported limitations in acquiring educational materials due to economic constraints
- 12% acknowledged that family economic limitations affected their educational continuity

Urban-rural gaps: Significant disparities persisted between urban and rural contexts:

- 50% of teachers identified limited access to technological resources as the primary factor differentiating rural and urban student performance
- 13% of university students from rural backgrounds reported difficulties using technological tools compared to urban peers
- 9% noted educational continuity challenges particularly affecting rural students

In the Table 4 shows the main gaps in the development of mathematical skills, according to teaching experience and Saber 11 tests, which directly influence the mastery of mathematical skills. After identifying the gap, the percentage and the mathematical skill affected are presented.

Table 4.
Distribution of students across SABER 11 mathematics proficiency levels (2021–2024).

Identified gap	Average number of teachers who identified the gap	Associated mathematical competence
Difficulty in problem solving	43%	Approach, modeling, and problem solving in diverse situations Ministerio de Educación Nacional [11].
Difficulty in reading comprehension in mathematical contexts	18%	Interpretation, formulation, and problem solving based on written information Organisation for Economic Co-operation and Development (OECD) [12].
Limited access to technological and digital resources	14%	Representation and modeling using technological resources to explore mathematical concepts Organisation for Economic Co-operation and Development (OECD) [12].
Weakness in abstract reasoning skills	11%	Ability to establish relationships, generalize, formulate conjectures, abstract properties, and justify procedures or results in various mathematical contexts. Ministerio de Educación Nacional [11].
Academic gaps left by the pandemic	11%	Ability to establish relationships, generalize, formulate conjectures, abstract properties, and justify procedures or results in various mathematical contexts. Ministerio de Educación Nacional [11].

The results reveal that difficulty in problem-solving (43%) constitutes the main gap identified by teachers, aligned with the competency of formulating, modeling, and solving problems in diverse situations. This is followed by reading comprehension in mathematical contexts (18%), evidencing that students face both conceptual and communicative barriers to tackle complex mathematical problems.

Technological gaps (14%) and abstract reasoning weaknesses (11%), along with academic gaps left by the pandemic (11%), configure a multifactorial landscape where problem-solving emerges as the articulating axis of all affected competencies.

3.3. Factors Influencing Mathematics Performance

Multiple interconnected factors emerged as significant influences on mathematics performance:

Emotional factors: Student surveys revealed concerning emotional dynamics in mathematics classrooms:

- 48% of students reported feeling confused during mathematics classes
- Only 21% expressed feeling secure and comfortable with teacher explanations
- 16% identified lack of attention as a barrier to learning

Pedagogical factors: Teachers' instructional approaches significantly impacted student outcomes:

- 46% of students emphasized the importance of clarity and quality in teacher explanations
- 54% of students reported depending primarily on teacher support when encountering difficulties
- 39% of teachers identified problem-solving as the most challenging competency to develop during remote learning

Technological factors: Access to and effective use of technology presented significant challenges:

- 96% of teachers reported limited access to technological resources (computers, internet, specialized classrooms, software) in their institutions
- 54% of teachers indicated heavy reliance on digital platforms (Zoom, Meet) during pandemic-era remote instruction
- Only 15% of students reported regular incorporation of dynamic exercises in mathematics classes

The findings that identified the factors affecting mathematical skills were obtained from the application of the instrument to 947 tenth and eleventh grade students from the educational institutions participating in this study see Table 5.

Table 5.
Key factors influencing mathematics performance identified through student surveys (n=947).

Factor Category	Specific Factor	% of Students Reporting	Impact on Learning
Emotional	The student feels confident and comfortable with the teacher's explanation.	21%	Students understand the teacher's explanation, which makes them feel confident and comfortable in math class.
	The student feels confused.	48%	Students say they feel confused in math class, which prevents them from learning effectively.
Teaching processes	The teacher's explanations are clear and of high quality.	46%	Students point out that the clarity and quality of the explanations provided by the teacher are a fundamental element in facilitating understanding of mathematics classes and enhancing learning.
	Dynamic exercises are incorporated into the classes.	15%	Students point out that incorporating dynamic exercises into mathematics classes significantly contributes to facilitating understanding of the content and promoting more effective learning.
	Students find it easier to learn mathematics after the pandemic	12%	Students report that the process of learning mathematics is more accessible in the post-pandemic period.
Time	Students spend an hour or more practicing math.	32%	Students indicate that they study or practice mathematics outside of school hours for one hour or more.
	Students do not spend time studying mathematics.	17%	Students say they do not spend time studying mathematics outside of school hours.
Dependence on teacher support	If students have any questions, they should ask their teacher.	54%	The students stated that when they have questions about mathematics, they turn to the teacher in class as their main source of support.

The Table 5 reflects different ways in which they influence disposition, participation, and learning, becoming determining factors for understanding academic dynamics. Likewise, they can facilitate or hinder the educational process, generating scenarios that impact both student performance and motivation. In this way, the information collected provides a basis for guiding pedagogical strategies that promote more favorable environments for learning mathematics.

3.4. Learning Difficulties in Mathematics

Analysis revealed a complex landscape of interconnected difficulties affecting mathematics learning:
Cognitive difficulties: Students demonstrated persistent challenges with:

- Reading comprehension in mathematical contexts (12% reported this as a primary barrier)
- Understanding problem statements and identifying relevant data (12%)
- Algebraic reasoning and calculus (35% identified these as the most difficult competencies)
- Trigonometric functions (20% reported significant gaps)

Metacognitive difficulties: Students struggled with higher-order learning processes:

- 11% demonstrated weaknesses in abstract reasoning abilities
- 7% showed difficulties retaining and transferring mathematical procedures to new situations
- 36% of teachers reported challenges developing argumentation and mathematical reasoning during remote learning

Structural difficulties: External factors significantly constrained learning opportunities:

- 96% of institutions reported limited access to technological resources
- 31% of students lacked adequate educational materials
- 17% of students reported unequal access to resources based on urban/rural context

4. Discussion

4.1. Mathematics Performance Recovery in the Post-Pandemic Context

The results reveal a modest recovery in mathematics performance between 2021 and 2024, although participating institutions continue to perform below the national average. While the proportion of students classified at the lowest proficiency level decreased slightly, progress toward the highest proficiency level remained limited, suggesting persistent difficulties in developing advanced mathematical reasoning and problem-solving competencies. These findings indicate

that learning recovery has occurred unevenly and that significant challenges remain in consolidating higher-order mathematical skills.

The observed trends are consistent with international evidence documenting the educational consequences of the COVID-19 pandemic. According to the OECD. PISA [3] mathematics was among the areas most affected by prolonged school closures because learning in this discipline depends heavily on cumulative conceptual development. Similarly, UNESCO [13] reported that many educational systems experienced significant learning losses that continued to affect student performance even after the reopening of schools. The findings of the present study align with these international trends, particularly regarding the persistence of achievement gaps and the difficulties associated with mathematical reasoning and problem-solving.

From a mathematics education perspective, the results support the argument that effective learning requires more than procedural knowledge. As Godino [7] emphasizes, mathematics instruction should promote conceptual understanding, reasoning, and the ability to apply knowledge in diverse contexts. The limited growth observed in advanced proficiency levels suggests that post-pandemic recovery efforts may have focused primarily on content coverage and remediation, while deeper cognitive processes received less attention. Consequently, educational improvement strategies should prioritize the development of analytical thinking, problem-solving skills, and mathematical reasoning rather than concentrating exclusively on performance indicators.

4.2. Educational Inequality and the Persistence of Achievement Gaps

One of the most significant findings of this study is the multidimensional nature of mathematics achievement gaps. The results demonstrate that socioeconomic conditions, geographical location, technological access, and previous learning opportunities interact to influence academic performance. Teachers consistently identified socioeconomic status and access to technological resources as critical factors affecting mathematics learning, while students highlighted limitations related to educational materials, connectivity, and learning support.

These findings are consistent with previous studies conducted in Colombia and Latin America. Pardo Mercado and Orjuela Albarracín [14] argue that educational inequalities reflected in SABER 11 results are strongly associated with structural conditions that shape students' educational trajectories. Likewise, the Laboratory of Economics of Education (LEE) [15] identified socioeconomic background, educational sector, and geographic location as significant predictors of performance disparities in national assessments.

International evidence supports these conclusions. UNICEF [16] and the Inter-American Development Bank [17] reported that the pandemic amplified pre-existing educational inequalities across Latin America, particularly among students from rural and economically vulnerable communities. The present study extends this body of knowledge by demonstrating how these structural inequalities are reflected not only in assessment outcomes but also in students and teachers' perceptions of the learning process.

The persistent urban-rural divide identified in this research deserves particular attention. Teachers reported that limited access to technological infrastructure and educational resources remains a major obstacle to mathematics learning in rural settings. These findings suggest that improving mathematics competencies requires more than pedagogical interventions; it also requires addressing structural inequities that restrict access to quality educational opportunities. Therefore, policies aimed at improving mathematics achievement should integrate educational, technological, and social dimensions to reduce the cumulative disadvantages experienced by vulnerable student populations.

4.3. Data-Informed Decision-Making as a Mechanism for Educational Improvement

A central contribution of this study is the demonstration that educational data can serve as a strategic resource for improving mathematics competencies when systematically analyzed and incorporated into decision-making processes. By combining SABER 11 performance data with stakeholder perceptions, the study provides a more comprehensive understanding of the factors influencing mathematics achievement in post-pandemic Colombia.

The findings support contemporary perspectives on educational leadership and data use. Antúnez and Imbernón [6] argue that educational transformation requires converting institutional data into collective knowledge capable of guiding pedagogical improvement. Similarly, Bernhardt [18] emphasizes that continuous school improvement depends on the systematic analysis of multiple sources of evidence rather than relying exclusively on intuition or isolated performance indicators.

The results suggest that most participating institutions continue to use assessment data primarily for descriptive purposes, focusing on what happened rather than why it happened or how future outcomes can be improved. This observation is consistent with recent developments in educational analytics, which advocate for a transition from descriptive reporting toward diagnostic, predictive, and prescriptive uses of educational data [19, 20]. Educational institutions that develop stronger data literacy capacities among teachers and school leaders are better positioned to identify learning needs, monitor interventions, and allocate resources effectively.

Consequently, strengthening data-informed decision-making should be considered a strategic priority for educational improvement. The integration of assessment results, contextual information, and stakeholder perspectives can support the design of targeted interventions aimed at reducing learning gaps and enhancing mathematics achievement in diverse educational contexts.

4.4. Pedagogical Implications for Mathematics Education

The findings reveal that emotional, pedagogical, and technological factors significantly influence mathematics learning. Nearly half of the surveyed students reported feeling confused during mathematics classes, while only a minority indicated feeling confident and comfortable with teacher explanations. These results suggest that affective dimensions play a critical role in shaping students' engagement with mathematics and their capacity to overcome learning difficulties.

This observation is consistent with Freire [21] perspective that meaningful learning occurs in educational environments where students feel respected, supported, and capable of participating actively in knowledge construction. Similarly, Boaler [22] argues that students' beliefs about their mathematical abilities influence their performance and willingness to engage in challenging tasks. The prevalence of confusion and insecurity identified in this study suggests the need for pedagogical approaches that strengthen both cognitive and emotional aspects of learning.

The findings also highlight the continued importance of teacher quality in post-pandemic educational recovery. Students consistently identified clear explanations and teacher support as fundamental elements for successful learning. These results align with Hattie and Zierer [23] synthesis of educational research, which identifies teacher effectiveness and feedback as among the most influential factors affecting student achievement.

At the same time, the limited incorporation of dynamic learning activities suggests that mathematics instruction remains predominantly teacher-centered. Contemporary research advocates for student-centered pedagogies that promote active participation, collaborative learning, and authentic problem-solving experiences [22, 24]. Such approaches contribute not only to improved conceptual understanding but also to greater motivation, engagement, and confidence in mathematics learning.

Particular attention should be directed toward strengthening problem-solving competencies, which emerged as the most significant challenge identified by teachers and were consistently associated with lower performance levels in standardized assessments. Developing these competencies is essential for preparing students to address complex real-world situations and participate effectively in knowledge-based societies.

4.5. Contribution of the Study and Future Research Directions

This study contributes to the growing body of research on post-pandemic educational recovery by integrating large-scale assessment data with stakeholder perceptions across diverse educational contexts in Colombia. The mixed-methods approach provided a comprehensive understanding of mathematics learning challenges and demonstrated the value of combining quantitative performance indicators with qualitative evidence derived from educational actors.

The findings contribute to the literature by highlighting the interconnected nature of learning recovery, educational inequality, pedagogical practices, and data-informed decision-making. While previous studies have examined these dimensions separately, the present research illustrates how they interact to shape mathematics achievement in post-pandemic educational settings.

Nevertheless, several limitations should be acknowledged. The study relied primarily on descriptive statistical analyses and self-reported perceptions, which may not fully capture the complexity of mathematics learning processes. Future research should incorporate inferential statistical techniques, longitudinal designs, and intervention-based approaches to explore causal relationships between educational practices and student outcomes.

Furthermore, emerging technologies such as learning analytics and artificial intelligence offer promising opportunities for supporting personalized mathematics instruction and improving educational decision-making. As Siemens, et al. [20] suggest, data-driven educational ecosystems have the potential to enhance learning outcomes through more precise identification of student needs and more effective allocation of institutional resources. Future studies should examine how these innovations can contribute to reducing educational inequalities and strengthening mathematics competencies in diverse educational contexts.

5. Conclusion

This study demonstrates that improving mathematics competencies in post-pandemic Colombia requires a multifaceted approach that integrates rigorous data analysis with context-sensitive pedagogical innovation. Four key conclusions emerge:

First, mathematics performance shows patterns of partial recovery but persistent underperformance relative to national averages, with particularly concerning deficits in higher-order competencies like problem-solving and mathematical reasoning. These findings demand targeted interventions that move beyond content remediation to address conceptual understanding and cognitive flexibility.

Second, achievement gaps operate across multiple intersecting dimensions—conceptual, socioeconomic, geographic, and technological—creating compounding disadvantages that require coordinated responses at classroom, institutional, and policy levels. Addressing these gaps demands recognition that educational inequality is not merely a matter of resource distribution but of systemic design.

Third, effective data management constitutes a critical but underutilized lever for educational improvement. Developing institutional capacity for diagnostic, predictive, and prescriptive data analysis—rather than limiting analysis to descriptive reporting—can transform assessment from an accountability mechanism into a tool for pedagogical innovation.

Fourth, mathematics pedagogy must evolve beyond procedural repetition toward approaches that foster conceptual understanding, emotional security, and real-world application. Drawing on successful models from contexts like Lajeado do Sul in Brazil [16]. Colombian educators can reimagine mathematics classrooms as spaces of exploration, creativity, and meaningful problem-solving.

These conclusions carry significant implications for educational practice and policy. Teachers require professional development focused on data literacy and innovative mathematics pedagogies. School leaders must cultivate data-informed cultures that support evidence-based decision-making. Policymakers should prioritize closing technological and resource gaps while creating flexibility for context-responsive instructional approaches. Most critically, all stakeholders must recognize that mathematics education is not merely about computational skill but about developing the analytical capacities essential for full participation in contemporary society.

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