

SPATIAL DISPARITIES IN NUMERACY LEARNING OUTCOMES USING THE GASING METHOD: A COMPARATIVE ANALYSIS BETWEEN RURAL HIGHLAND AND URBAN COASTAL REGIONS IN PAPUA, INDONESIA

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ABSTRAK

Ketimpangan geografis dan keterbatasan akses pendidikan menjadi tantangan dalam pemerataan hasil belajar numerasi, khususnya di wilayah terpencil Papua. Penelitian ini bertujuan menganalisis kesenjangan hasil belajar numerasi dan peningkatan skor setelah penerapan metode GASING (*Gampang, Asyik, dan Menyenangkan*) pada wilayah dataran tinggi perdesaan dan pesisir perkotaan. Penelitian menggunakan desain kuasi-eksperimental komparatif dengan pengukuran *pre-test* dan *post-test*, melibatkan 153 guru dan 311 siswa dari Kabupaten Nduga dan Kota Jayapura. Pengukuran mencakup lima domain numerasi, yaitu kemampuan dasar berhitung, penjumlahan, perkalian, pengurangan, dan pembagian. Hasil penelitian menunjukkan bahwa rata-rata skor *post-test* guru di Jayapura mencapai 78,2, sedangkan di Nduga sebesar 57,0. Pada siswa, rata-rata skor masing-masing wilayah adalah 61,1 dan 50,1. Meskipun kesenjangan hasil akhir masih terlihat, selisih peningkatan skor siswa hanya 0,4 poin, dibandingkan 9,3 poin pada guru. Analisis multidimensional mengidentifikasi lokasi geografis, aksesibilitas, dan literasi digital sebagai aspek kesenjangan utama. Temuan ini menunjukkan potensi metode GASING dalam mendukung pemerataan peningkatan numerasi siswa, sekaligus menegaskan perlunya dukungan infrastruktur dan akses pendidikan yang memadai.

Kata kunci: kesenjangan spasial, numerasi, metode GASING, pemerataan pendidikan, Papua

ABSTRACT

Geographical inequalities and limited access to educational resources remain major challenges to equitable numeracy learning, particularly in remote areas of Papua, Indonesia. This study aimed to analyze disparities in numeracy learning outcomes and score improvements following the implementation of the GASING (*Gampang, Asyik, dan Menyenangkan*) method in rural highland and urban coastal regions. A comparative quasi-experimental design with *pre-test* and *post-test* measurements was employed, involving 153 teachers and 311 students from Nduga Regency and Jayapura City. Assessment covered five numeracy domains: counting foundations, addition, multiplication, subtraction, and division. The results showed that the mean teacher *post-test* score reached 78.2 in Jayapura, compared with 57.0 in Nduga. Among students, the respective mean scores were 61.1 and 50.1. Although disparities in final achievement remained, the difference in student gain scores was only 0.4 points, compared with 9.3 points among teachers. Multidimensional analysis identified geographical location, accessibility, and digital literacy as major areas of disparity. These findings indicate the potential of the GASING method to support more equitable improvements in student numeracy while highlighting the need for adequate infrastructure and educational access to address persistent spatial inequalities.

Keywords: spatial disparities, numeracy, GASING method, educational equity, Papua



INTRODUCTION

Educational equity remains a major challenge in developing countries, particularly in regions characterized by geographical fragmentation, unequal infrastructure, and socioeconomic disparities. Equal access to schooling does not necessarily guarantee equal learning opportunities or outcomes because educational achievement is also shaped by the availability of learning resources, teacher support, and the conditions in which instruction takes place. In Indonesia, these challenges are particularly relevant because the country's archipelagic geography creates logistical barriers to the distribution of educational services. Research on educational achievement in Indonesia indicates that school quality and ethnic diversity are associated with differences in student outcomes (Muttaqin et al., 2022). Similarly, Beatty et al. (2021) documented persistent weaknesses in Indonesian students' learning outcomes despite improvements in school participation. These findings demonstrate that educational equity should be assessed not only through access to schooling but also through differences in learning achievement across geographical and institutional contexts.

Numeracy is a fundamental competency that enables students to understand numbers, perform arithmetic operations, and apply mathematical knowledge in everyday situations. Weaknesses in foundational numeracy can constrain subsequent mathematical learning and reduce students' opportunities to develop broader academic competencies. The OECD (2023), through the *Programme for International Student Assessment (PISA) 2022* results, emphasized the importance of examining learning achievement alongside educational equity. In Indonesia, the challenge is particularly complex because differences in school infrastructure, teacher distribution, and access to instructional resources may limit students' opportunities to develop mathematical competencies. These structural conditions are especially relevant in Papua, where geographical isolation and uneven access to educational services create substantial barriers for remote communities. Maharani (2021), in a study of school participation in Merauke Regency, examined factors associated with educational participation, highlighting the importance of considering contextual conditions when evaluating educational access. Accordingly, numeracy disparities in Papua need to be understood in relation to both students' learning outcomes and the geographical environments in which teaching and learning occur.

The contrast between rural highland and urban coastal regions provides an important perspective for examining these disparities. Remote highland communities may face restricted transportation, limited electricity, weak digital connectivity, and fewer opportunities for teacher professional development. By comparison, urban areas generally have better access to transportation networks, educational institutions, and learning resources. Such differences can influence the implementation of instructional interventions and the extent to which teachers and students benefit from them. Haryati et al. (2025) examined mathematics learning activities in urban and rural Indonesian elementary schools, providing a relevant basis for considering differences in learning environments across geographical settings. These contextual differences suggest that variations in numeracy achievement cannot be attributed exclusively to students' abilities or the instructional methods employed. Instead, learning outcomes should also be examined in relation to the spatial and institutional conditions that support or constrain educational processes.

One instructional approach that may support the development of foundational numeracy is the GASING method (*Gampang, Asyik, dan Menyenangkan*), which emphasizes a gradual progression from concrete experiences to abstract mathematical understanding. This approach is relevant to students who experience difficulties with conventional instruction that introduces numerical symbols and procedures before establishing conceptual understanding. Mainali (2021) highlighted the importance of representation in mathematics teaching and learning, supporting the use of multiple representations to facilitate students' understanding of mathematical concepts. In a

similar vein, Prahmana and Suwasti (2014) developed a local instructional theory for teaching division through Mathematics GASING in a rural Indonesian context. Their work illustrates the importance of connecting arithmetic procedures with concrete situations before introducing abstract algorithms. These pedagogical principles provide a rationale for examining whether GASING can support numeracy development among learners in geographically and educationally contrasting environments.

Previous studies have also examined the application of GASING in teacher training and mathematics education. Mulyawati and Sarwinda (2021) reported on a GASING mathematics workshop for elementary school teachers in East Jakarta, while Nursakiah and Bahar (2021) investigated training in the application of GASING to addition, subtraction, multiplication, and division. These studies provide a foundation for understanding the potential of structured GASING instruction to support the development of basic arithmetic competencies. Nusantara et al. (2022) further examined the effectiveness of the GASING mathematics approach in relation to numeracy skills in rural Papua. In addition, Surya (2023) discussed GASING as a structured approach to numeracy for marginalized communities. Taken together, this literature establishes the relevance of GASING as an instructional approach for strengthening basic mathematical competencies, particularly in settings where learners require systematic support in understanding arithmetic operations.

Despite these contributions, improvements observed within individual training programs or particular educational settings do not necessarily demonstrate that the same intervention produces comparable learning trajectories across different geographical contexts. Evidence concerning educational disparities in Indonesia, differences between urban and rural mathematics learning environments, and the implementation of GASING addresses important aspects of the problem, but these strands need to be considered together to understand the relationship between instructional outcomes and spatial inequality. In particular, comparisons between remote highland and urban coastal communities need to distinguish differences in final achievement from differences in learning gains. Learners who begin with substantially different levels of prior knowledge may achieve similar improvements while continuing to exhibit unequal post-intervention scores. Examining both measures is therefore essential for determining whether an instructional intervention can support more equitable learning progress without assuming that it eliminates the structural disadvantages affecting educational achievement.

The present study addresses this gap by comparing GASING implementation outcomes in Kabupaten Nduga, a remote highland region of Papua, and Kota Jayapura, an urban coastal center. These sites represent contrasting geographical and educational environments, particularly in terms of physical accessibility, infrastructure, digital connectivity, and access to educational support. The study involves teachers and elementary school students, allowing the analysis to distinguish between changes in teachers' numeracy competencies and changes in students' learning outcomes. It also examines five fundamental numeracy domains: counting foundations, addition, multiplication, subtraction, and division. By comparing *pre-test* and *post-test* scores and examining gain scores, the study evaluates both differences in achievement levels and differences in learning progress following GASING implementation.

In addition to assessing numeracy outcomes, this study examines spatial disparities through geographical, social, and educational dimensions. This multidimensional perspective is intended to identify the contextual differences that characterize the two sites and to clarify how these differences correspond with observed patterns of learning achievement. The study is guided by three objectives: (1) to compare teacher and student numeracy outcomes across the five domains in Nduga and Jayapura; (2) to analyze differences in learning gains following GASING implementation between the two locations; and (3) to identify the geographical, social, and educational disparities associated with the contrasting learning environments. By integrating

comparative pedagogical evaluation with spatial analysis, this research contributes evidence on the potential and limitations of GASING as an approach to numeracy improvement in geographically unequal settings. The findings are expected to inform the development of context-sensitive educational interventions that combine appropriate teaching strategies with improvements in infrastructure, accessibility, and professional support for teachers in remote communities.

METHODS

This study employed a comparative quasi-experimental design using a one-group *pre-test* and *post-test* approach at two geographically contrasting research sites in Papua, Indonesia. The study was conducted in Kabupaten Nduga, representing a rural highland region, and Kota Jayapura, representing an urban coastal region. The GASING training program in Nduga took place from 25 July to 13 August 2024, while the program in Jayapura was conducted from 23 November to 12 December 2023. The sites were purposively selected to examine differences in numeracy learning outcomes under contrasting geographical, social, and educational conditions.



Figure 1. Spatial Dimension Analysis: Location, Accessibility, and Geographic Environment Disparities between Rural Highland (Nduga) and Urban Coastal (Jayapura) Research Sites.

The study involved 464 participants, comprising 153 primary school teachers and 311 students. The teacher cohort included 68 teachers from Nduga and 85 from Jayapura, although only 64 Jayapura teachers were reported as included in the analysis. The student cohort consisted of 144 students from Nduga and 167 from Jayapura. Participant biodata were used to describe demographic, professional, and contextual characteristics relevant to comparisons between the two locations.

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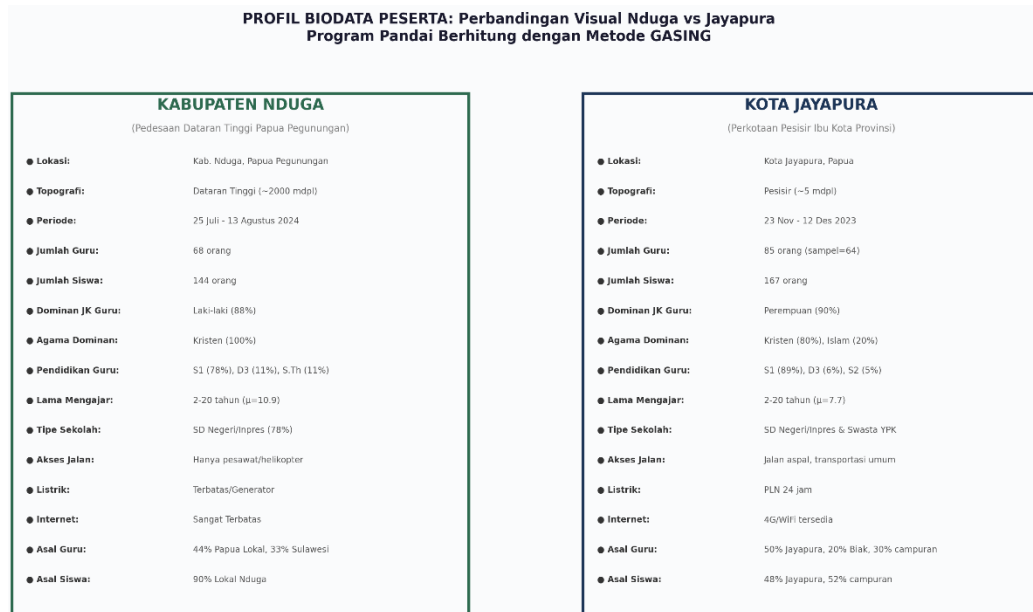


Figure 2. Comparative Biodata Profiles of GASING Program Participants: Kabupaten Nduga (Rural Highland) and Kota Jayapura (Urban Coastal).

The social dimension analysis considered gender, religious composition, ethnic background, teaching experience, digital literacy, and access to professional development. The educational dimension analysis examined teacher qualifications, school types, student grade distribution, subject specialization, and school infrastructure. These indicators were used to characterize differences in the learning environments of the two research sites.

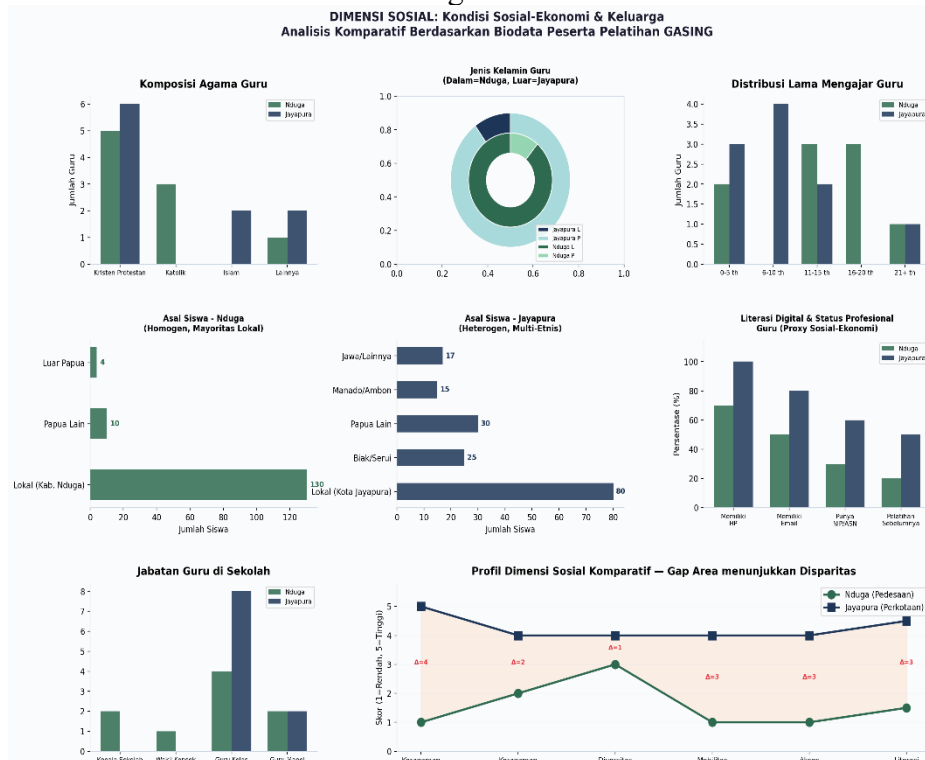


Figure 3. Social Dimension Analysis: Comparative Profiles of Socioeconomic Conditions and Community Context Based on GASING Training Participant Biodata.

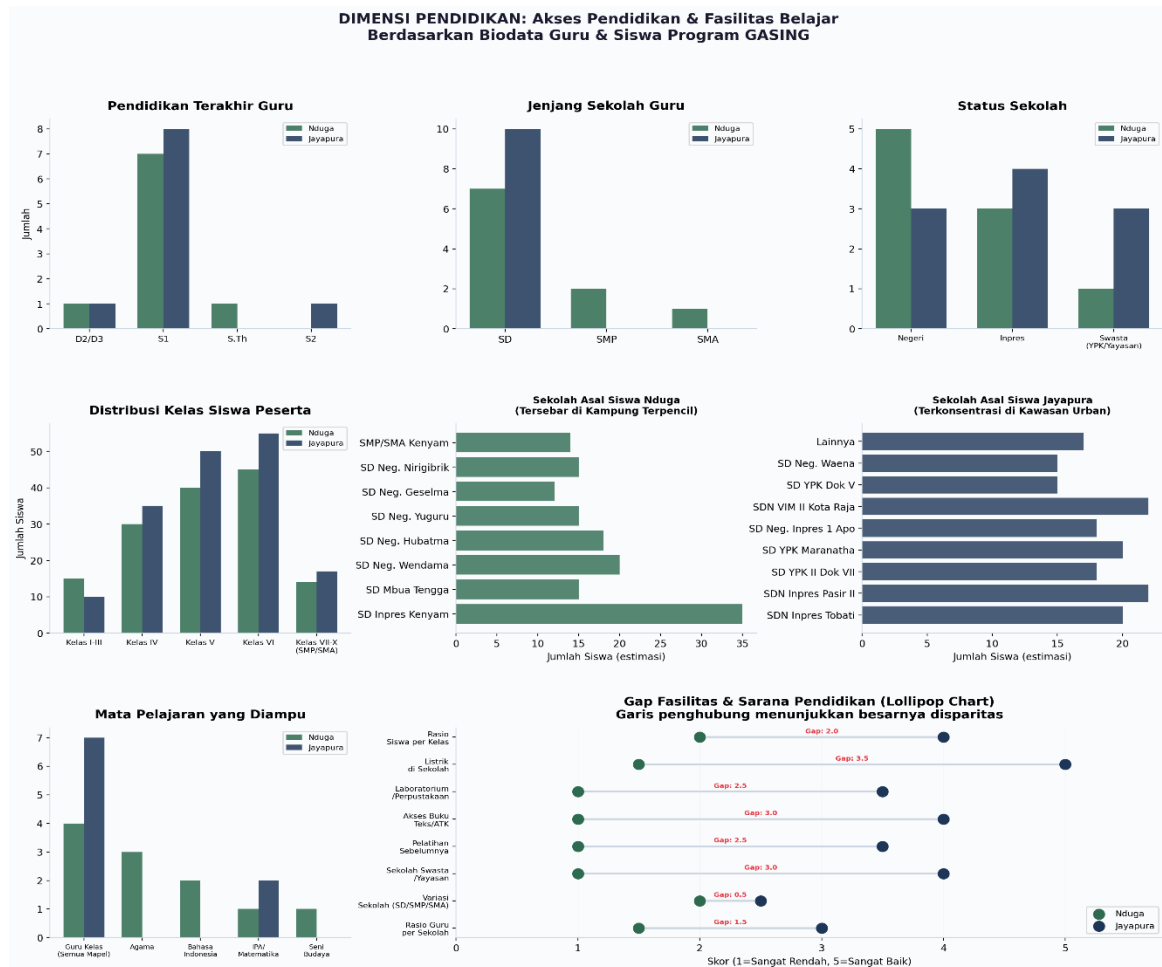


Figure 4. Educational Dimension Analysis: Access to Education and Learning Facilities Based on Teacher and Student Biodata from the GASING Program.

Data were collected using a standardized numeracy assessment administered before and after the GASING training. The instrument covered five domains: counting foundations (*Bakal Kubagi*), addition, multiplication, subtraction, and division. Each domain was assessed using specific test items, and the resulting scores were converted to a scale of 0–100. The *pre-test* was administered before the instructional intervention, while the *post-test* was administered at the end of the training. Participant biodata and contextual indicators provided supplementary information for the geographical, social, and educational comparisons.

Data analysis used descriptive statistics, including mean scores, differences between locations, gain scores, frequency distributions, and percentages of participants attaining a *post-test* score of at least 60. Comparisons were conducted separately for teachers and students across the five numeracy domains. Gain scores were calculated as the difference between *post-test* and *pre-test* scores. To examine multidimensional disparities, geographical, social, and educational indicators were assessed using a composite scale ranging from 1 to 5, and the resulting profiles were compared between Nduga and Jayapura. Findings were presented through comparative charts, score distributions, heatmaps, and disparity profiles. Because the study used a non-randomized, one-group design at each site, the findings were interpreted as comparative patterns associated with the intervention and the research contexts rather than definitive causal effects.

RESULTS AND DISCUSSION

Results

Pre-test and Post-test Numeracy Performance

The comparison of pre-test and post-test scores provides an overview of numeracy performance among teachers and students participating in the GASING program in Nduga and Jayapura. The analysis covers five numeracy domains: counting foundations (*Bakal Kubagi*), addition, multiplication, subtraction, and division. Examining these domains separately allows the study to identify differences in initial competencies and post-training achievement between the rural highland and urban coastal settings.

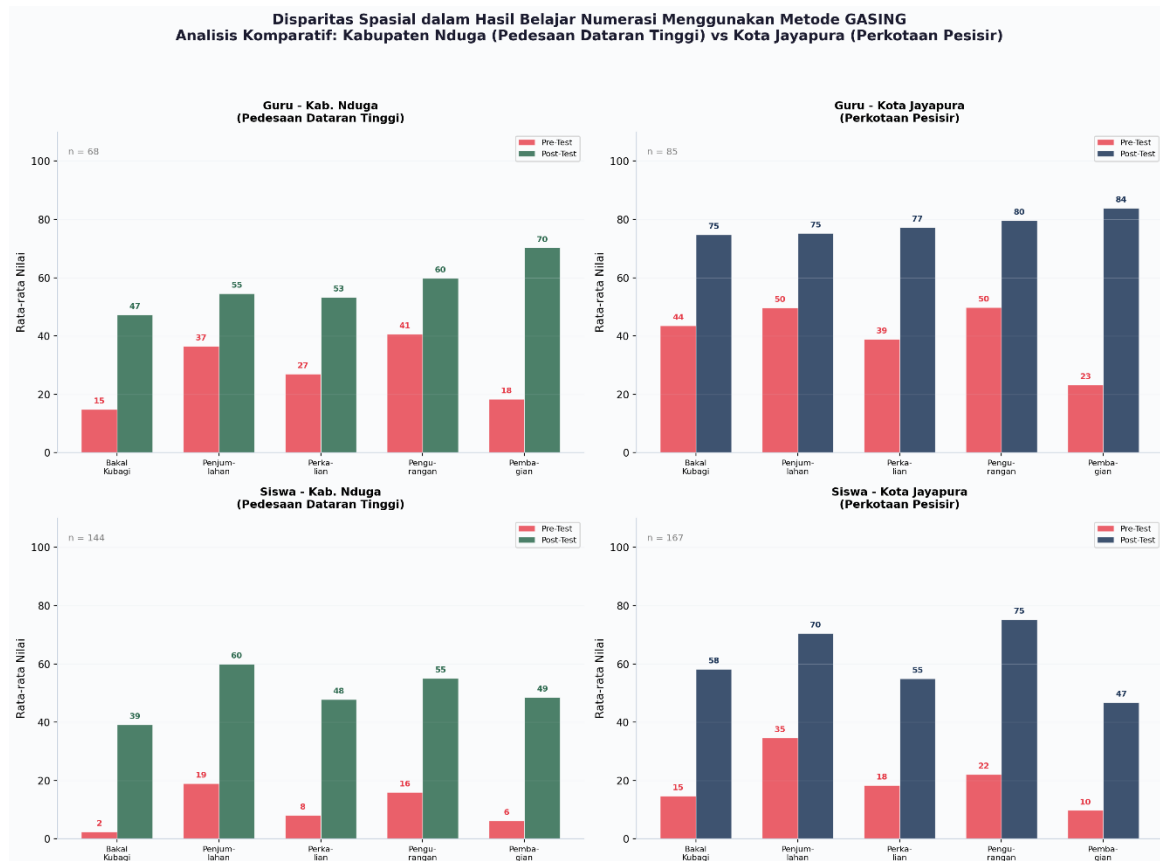


Figure 5. Pre-test and Post-test Mean Score Comparison across Five Numeracy Domains for Teachers and Students in Nduga (Rural Highland) and Jayapura (Urban Coastal).

Figure 5 illustrates a consistent difference in numeracy performance between the two research sites. Among teachers, Nduga participants recorded pre-test scores ranging from 15 in counting foundations to 41 in subtraction, whereas Jayapura teachers scored between 23 in division and 50 in addition and subtraction. Following the GASING program, teacher post-test scores increased to a range of 47–70 in Nduga and 75–84 in Jayapura, indicating higher final achievement among teachers in the urban coastal setting.

A similar pattern was observed among students, although their overall scores remained lower than those of teachers. Nduga students recorded pre-test scores ranging from 2 in counting foundations to 19 in addition, compared with scores ranging from 10 in division to 35 in addition among Jayapura students. Their post-test scores increased to 39–60 in Nduga and 47–75 in Jayapura, indicating that the difference in final achievement persisted after the intervention. The reported average pre-test and post-test gaps were 13.5 and 21.2 points for

teachers, respectively, and 9.6 and 11.1 points for students. These patterns indicate that improvement following GASING implementation did not eliminate the initial differences in numeracy achievement between the two locations.

Comparative Gain Score Analysis

Differences in final achievement do not necessarily indicate differences in the magnitude of learning improvement. Therefore, gain scores were examined to determine whether teachers and students in Nduga and Jayapura experienced comparable changes between the pre-test and post-test assessments. This analysis distinguishes the absolute level of achievement from the amount of improvement observed during the GASING program.

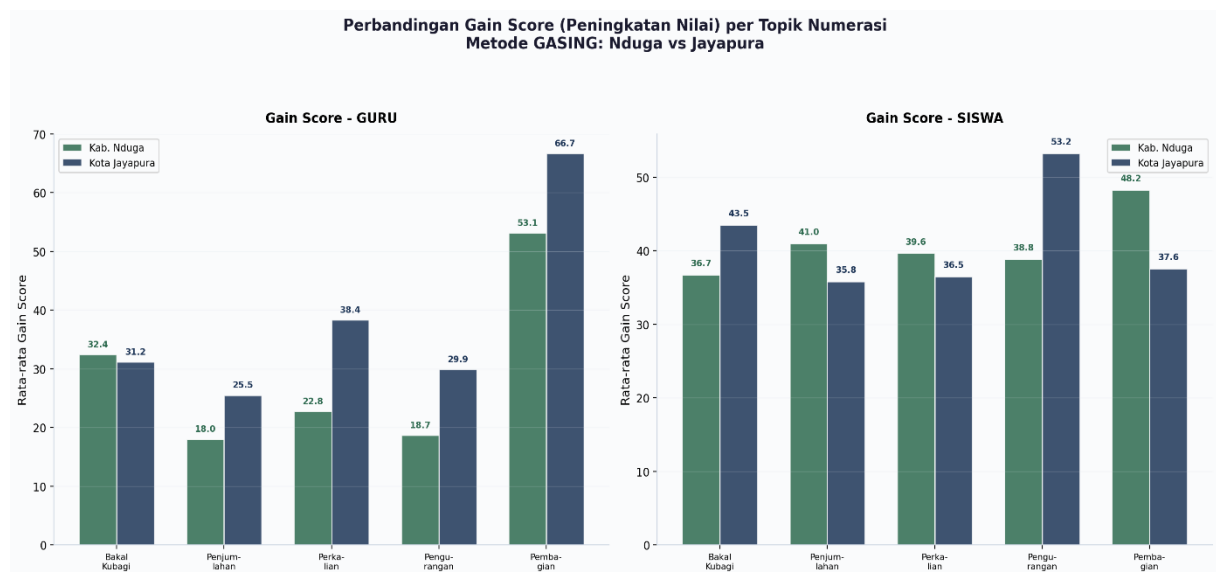


Figure 6. Comparative Gain Scores (Score Improvement) per Numeracy Topic Using the GASING Method: Nduga versus Jayapura.

Figure 6 reveals different patterns of improvement between teachers and students. Among teachers, Jayapura recorded higher gain scores in all five numeracy domains, with particularly large differences in multiplication (38.4 versus 22.8), division (66.7 versus 53.1), and subtraction (29.9 versus 18.7). The reported average teacher gain was 38.3 points in Jayapura and 29.0 points in Nduga, resulting in a 9.3-point difference. This pattern indicates that teacher improvement was greater in the urban coastal setting, although the descriptive comparison alone cannot establish which contextual factors caused the difference.

In contrast, student gain scores were relatively similar between the two sites. Nduga students recorded higher gains in addition (41.0 versus 35.8), multiplication (39.6 versus 36.5), and subtraction (38.8 versus 37.6), whereas Jayapura students recorded higher gains in counting foundations (43.5 versus 36.7) and division (48.2 versus 37.6). The reported average student gains were 40.9 points in Nduga and 41.3 points in Jayapura, producing a difference of only 0.4 points. This result suggests that students in the two locations experienced broadly comparable improvements in overall numeracy scores despite differences in their final achievement levels. However, the interpretation should remain descriptive because the study did not include a randomized comparison group.

Numeracy Competency Profiles across Domains

To complement the gain score analysis, the post-test competency profiles were examined across the five numeracy domains. This comparison provides a more integrated view of the relative strengths and weaknesses of each participant group. It also helps identify

whether the observed regional differences were concentrated in particular arithmetic operations or extended across the full range of assessed competencies.

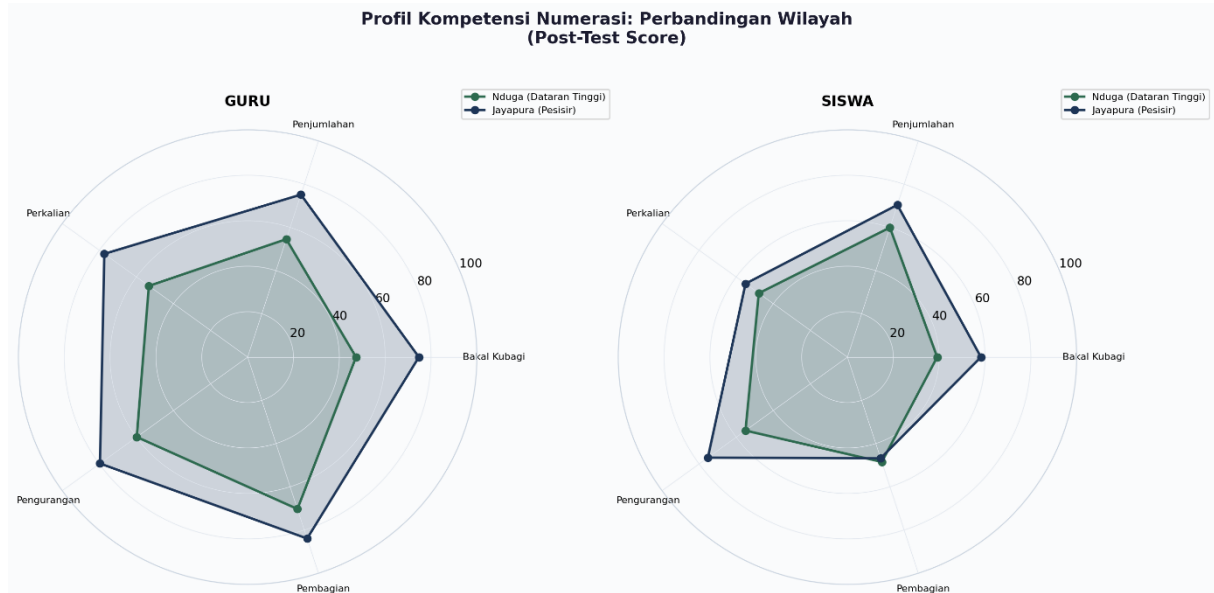


Figure 7. Numeracy Competency Profile: Regional Comparison of Post-test Scores for Teachers and Students across Five Domains.

Figure 7 shows that Jayapura teachers achieved higher post-test scores across all five domains, with scores ranging from 75 to 84. Nduga teachers recorded lower scores, ranging from 47 to 70, indicating that the regional difference extended across the assessed numeracy competencies rather than being restricted to one arithmetic operation. Division was the highest-scoring domain for both teacher groups, with scores of 84 in Jayapura and 70 in Nduga. This pattern identifies division as a relative strength in the teacher post-test profiles, although the scores alone do not establish why performance in this domain was comparatively high.

The student profiles display a narrower range of differences than the teacher profiles, but Jayapura students still achieved higher post-test scores across the five domains. In Jayapura, addition and subtraction were relative strengths, with scores of 70 and 75, respectively, whereas division recorded a lower score of 47. Nduga students showed lower overall achievement, with post-test scores ranging from 39 to 60. The relatively low division scores among students in both locations suggest that further instructional attention may be needed for this operation. Overall, the competency profiles reinforce the distinction between the relatively similar student gains and the persistent differences in absolute post-test performance.

Post-test Score Distribution and Variability

Mean scores provide an overview of overall performance but do not show how scores are distributed among individual participants. The distributional analysis therefore examines differences in central tendency, variability, and extreme scores across the two locations. This is particularly relevant because participants in geographically different settings may exhibit heterogeneous learning outcomes even when they receive the same general instructional approach.

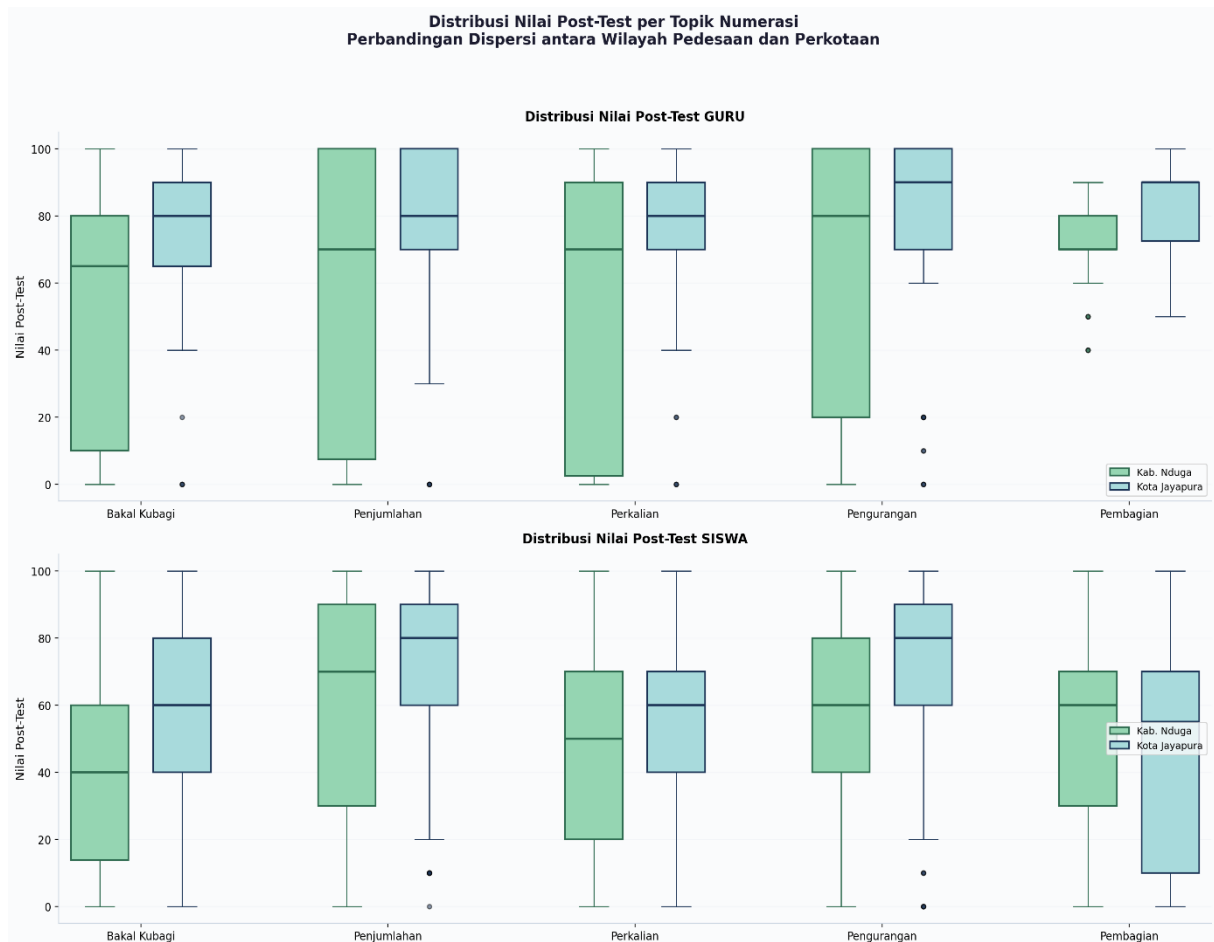


Figure 8. Post-test Score Distribution per Numeracy Topic: Comparison of Dispersion between Rural and Urban Regions for Teachers and Students.

Figure 8 indicates differences in the distribution of post-test scores between the two research sites. The reported box plots show wider distributions and more pronounced lower-end values in Nduga, whereas Jayapura scores tend to cluster at higher levels. This pattern suggests greater heterogeneity in the outcomes of participants in the highland setting, with some individuals achieving substantially lower scores than others. Such variation is important because regional mean scores may conceal the presence of participants who continue to experience considerable difficulties with foundational numeracy.

Among teachers, the reported median scores were approximately 65–80 in Nduga and 75–90 in Jayapura across the assessed domains. Among students, the corresponding median ranges were approximately 40–70 and 55–80. The presence of scores near the lower boundary in Nduga also suggests that not all participants reached comparable levels of achievement following the program. Nevertheless, differences in score dispersion should be interpreted as descriptive evidence of outcome heterogeneity rather than direct proof that geographical conditions caused the observed variation. Individual learning histories, participation, and opportunities for continued practice may also contribute to these patterns.

Heatmap Analysis of Pre-test and Post-test Scores

The heatmap analysis provides a consolidated visual comparison of mean scores before and after the GASING program. By arranging the results according to participant group and numeracy domain, the visualization makes it possible to examine baseline

differences and subsequent score changes simultaneously. This presentation also helps identify domains in which low initial scores were followed by comparatively substantial improvements.

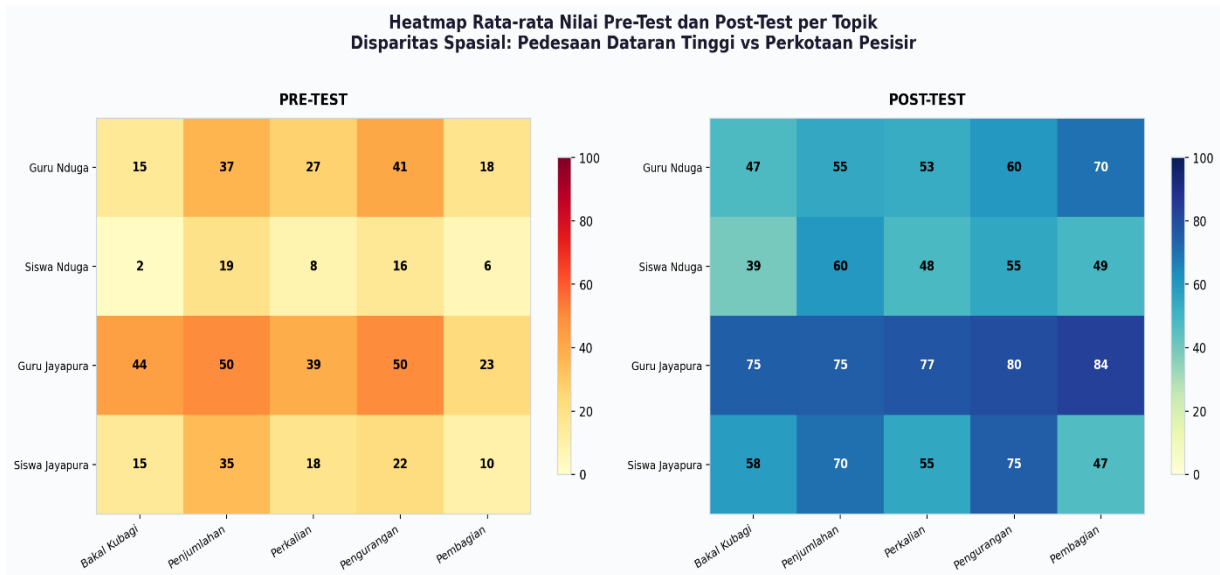


Figure 9. Heatmap of Mean Pre-test and Post-test Scores per Topic: Spatial Disparity between Rural Highland and Urban Coastal Regions.

Figure 9 shows a general shift from lower pre-test scores to higher post-test scores across the four participant groups. The change is particularly noticeable among Nduga students, whose reported initial scores ranged from 2 to 19 before increasing to a range of 39–60 after the program. Jayapura participants also demonstrated higher post-test scores, although their initial performance was generally higher than that of their Nduga counterparts. The heatmap therefore supports the finding that score improvements occurred in both geographical settings while differences in final achievement remained.

The domain-level patterns further indicate that changes varied across arithmetic operations and participant groups. Division showed substantial improvement among teachers, particularly in Jayapura, consistent with the gain score analysis. However, the relatively low student post-test scores in division indicate that improvement did not necessarily correspond to mastery of the operation. The color transitions should therefore be interpreted as a visual representation of changes in mean performance rather than independent statistical evidence of intervention effectiveness. Taken together, the heatmap reinforces the importance of examining both learning gains and final achievement when evaluating educational interventions across unequal settings.

Relationship between Pre-test and Post-test Scores

The relationship between individual pre-test and post-test scores provides additional information about the consistency of learning improvement within each participant group. A scatter plot allows the distribution of individual observations to be examined in relation to the diagonal reference line, which represents equal pre-test and post-test scores. Observations above this line indicate higher post-test scores, whereas observations below it indicate lower post-test scores.

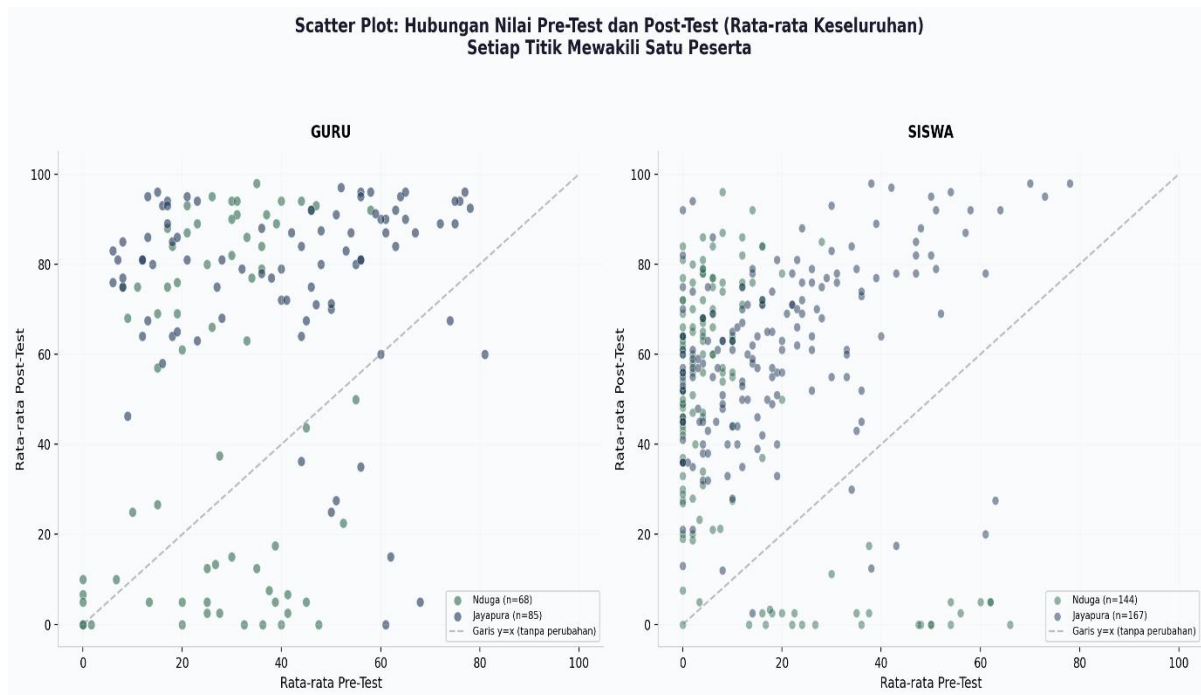


Figure 10. Scatter Plot: Relationship between Pre-test and Post-test Scores (Overall Mean), with Each Point Representing an Individual Participant.

Figure 10 shows that many observations are positioned above the equality line, indicating that participants obtained higher scores after the GASING program. Among teachers, the Jayapura observations are concentrated at comparatively higher pre-test and post-test levels, while Nduga observations extend across a wider range of scores. This distribution is consistent with the higher average post-test achievement in Jayapura and the greater variability reported for Nduga. Some Nduga teacher observations remain concentrated near the lower end of the score range, indicating that improvement was not uniform across all participants.

Among students, the scatter plot shows a wider spread of post-test scores among participants with similarly low initial scores in Nduga. This pattern indicates heterogeneous outcomes within the highland group, even among learners who began with limited demonstrated numeracy competency. Jayapura students are more frequently represented in the higher-score region, consistent with their higher average post-test performance. Nevertheless, the scatter plot cannot identify the causes of individual differences because information on attendance, home learning support, and prior informal learning was not directly analyzed as explanatory variables. The results instead indicate that future evaluations should consider individual-level factors alongside regional context when examining variation in learning progress.

Consolidated Summary of Spatial Achievement Gaps

The preceding analyses show that regional differences can be understood through three complementary measures: initial achievement, final achievement, and score improvement. Bringing these measures together clarifies whether the observed differences primarily reflect unequal starting points, unequal learning gains, or both. This integrated comparison is particularly important for distinguishing persistent achievement gaps from differences in the trajectories observed during the intervention.

Ringkasan Statistik Disparitas Spasial Hasil Belajar Numerasi Metode GASING: Pedesaan Dataran Tinggi (Nduga) vs Perkotaan Pesisir (Jayapura)						
Metrik	Guru Nduga	Guru Jayapura	Δ (Gap)	Siswa Nduga	Siswa Jayapura	Δ (Gap)
Jumlah Peserta	68	85	-	144	167	-
Rata-rata Pre-Test	27.5	41.0	13.5	10.3	19.9	9.6
Rata-rata Post-Test	57.0	78.2	21.1	50.1	61.1	11.1
Rata-rata Gain Score	29.0	38.3	9.3	40.9	41.3	0.4

Figure 11. Statistical Summary of Spatial Disparities in Numeracy Learning Outcomes Using the GASING Method: Rural Highland (Nduga) versus Urban Coastal (Jayapura).

Figure 11 summarizes the contrasting patterns of achievement and improvement across the two participant groups. For teachers, the average regional gap increased from 13.5 points at pre-test to 21.2 points at post-test, while the reported difference in average gains was 9.3 points in favor of Jayapura. For students, the average regional gap increased from 9.6 to 11.1 points, despite a difference in average gain scores of only 0.4 points. These findings demonstrate that relatively similar improvement can coexist with unequal final achievement when participants begin at different competency levels.

The contrast between the teacher and student results is an important feature of the comparative analysis. Teacher gains were more favorable in Jayapura, whereas student gains were nearly equal across the two sites. However, the remaining post-test differences show that comparable short-term improvement did not automatically produce comparable levels of numeracy achievement. The findings therefore suggest that evaluating equity requires attention to both the progress made during an intervention and the competency levels ultimately attained. Because the reported statistics are descriptive, additional inferential analyses would be required to determine the statistical significance of the regional differences.

Numeracy Mastery Achievement

In addition to mean scores and gain scores, the study examined the proportion of participants reaching a post-test score of at least 60. This threshold provides a descriptive indicator of the extent to which participants attained the specified minimum score in each numeracy domain. Comparing these proportions across teachers, students, and locations helps identify areas in which further learning support may be needed.

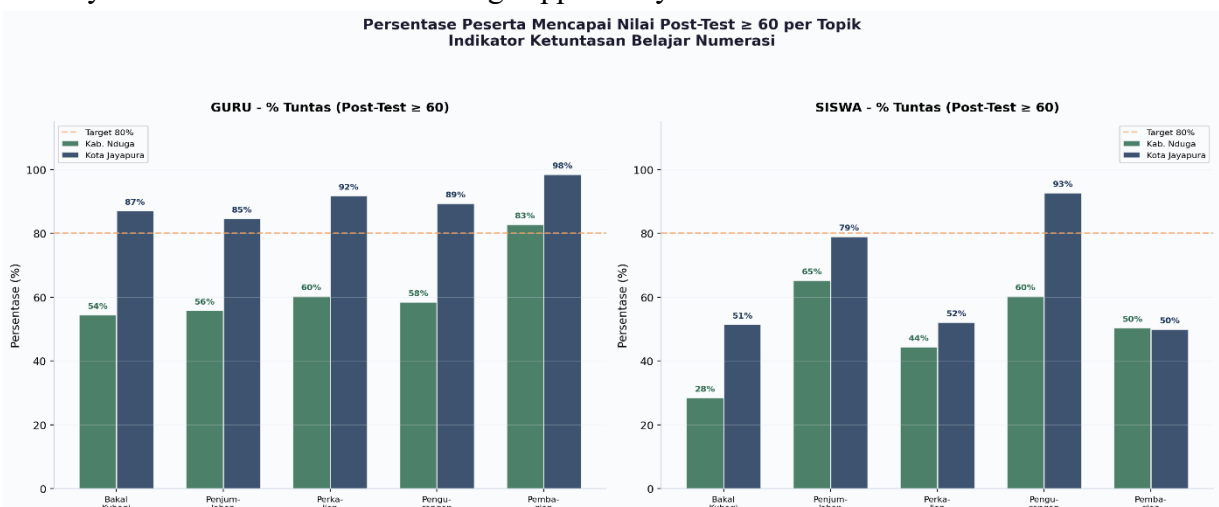


Figure 12. Percentage of Participants Achieving Post-test Score ≥ 60 per Topic: Numeracy Learning Mastery Indicator for Teachers and Students.

Figure 12 indicates that the proportion of teachers reaching the score threshold was generally higher in Jayapura than in Nduga. The reported Jayapura teacher attainment rates ranged from 85% to 98%, whereas Nduga teacher rates ranged from 54% to 83%. Division recorded the highest reported attainment rate among Nduga teachers at 83%, suggesting comparatively stronger performance in this domain. These results indicate that differences in post-test achievement were reflected not only in average scores but also in the proportions of teachers reaching the specified threshold.

The student results reveal a more substantial challenge in achieving the designated score threshold across both sites. The reported attainment rates varied by numeracy domain, with counting foundations among Nduga students reaching 28% and among Jayapura students reaching 51%. Division was also identified as an area of concern, with reported attainment rates of 50% for students in both locations. These patterns suggest that foundational counting skills and division require continued instructional attention, even where the average student gain scores were relatively similar. The reported percentages should be checked against the original participant-level data before final publication, particularly where the stated attainment rates appear inconsistent with the corresponding mean scores or with the stated 80% benchmark.

Integrated Multidimensional Analysis of Spatial Disparities

The final analysis brings together geographical, social, and educational indicators to contextualize the differences in numeracy outcomes between Nduga and Jayapura. Whereas the preceding sections focus primarily on assessment scores, this analysis considers the broader conditions that may be associated with differences in learning opportunities. The combined profile provides a descriptive basis for identifying contextual dimensions that warrant attention when planning numeracy interventions in geographically unequal settings.

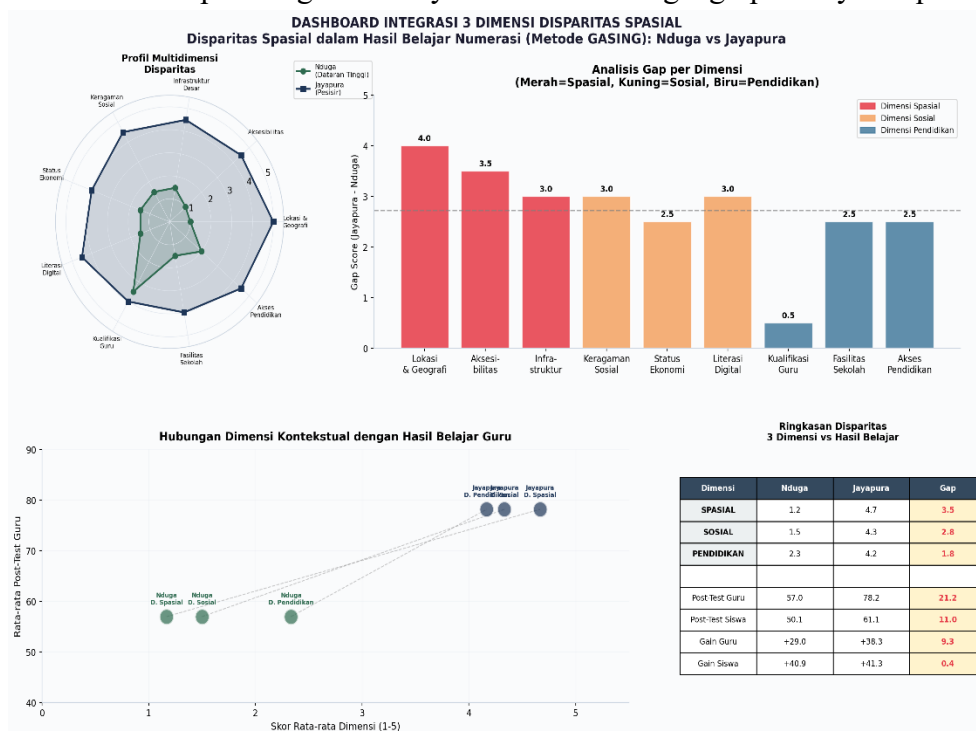


Figure 13. Integrated Three-Dimensional Disparity Dashboard: Spatial Disparities in Numeracy Learning Outcomes Using the GASING Method across Spatial, Social, and Educational Dimensions in Nduga and Jayapura.

Figure 13 presents differences across the three contextual dimensions, with the largest reported gap occurring in the spatial dimension. The composite scores were 1.2 for Nduga and 4.7 for Jayapura in the spatial dimension, producing a gap of 3.5 points on the reported five-point scale. The social dimension showed a gap of 2.8 points, based on scores of 1.5 for Nduga and 4.3 for Jayapura, while the educational dimension showed a gap of 1.8 points, based on scores of 2.3 and 4.2, respectively. These descriptive profiles indicate that the two sites differed across multiple contextual dimensions rather than in numeracy achievement alone.

At the indicator level, the reported largest differences concerned location and geography (4.0 points), accessibility (3.5 points), digital literacy (3.0 points), social diversity (3.0 points), and infrastructure (3.0 points). Teacher qualifications showed a smaller reported gap of 0.5 points, suggesting that differences in formal credentials alone may not adequately describe the contrasting educational environments. The dashboard also indicates a positive association between contextual scores and post-test outcomes, although the strength and statistical significance of this relationship cannot be established from the visualization alone. Overall, the integrated analysis highlights the importance of considering geographic access, infrastructure, digital resources, and educational support when interpreting regional differences in numeracy achievement.

Pembahasan

Spatial Disparities in Numeracy Achievement

The findings demonstrate persistent differences in numeracy achievement between Nduga and Jayapura following the implementation of the GASING method. Teachers in Jayapura achieved a mean post-test score of 78.2, compared with 57.0 in Nduga, while student scores reached 61.1 and 50.1, respectively. These differences indicate that the learning outcomes of participants in the two regions remained unequal despite their participation in the same general instructional program. The larger achievement gap among teachers also suggests that differences in professional learning outcomes warrant particular attention when designing numeracy interventions for geographically disadvantaged schools.

These findings are consistent with the broader evidence that educational participation does not automatically translate into equivalent learning outcomes. Beatty et al. (2021) documented persistent weaknesses in Indonesian students' learning outcomes, while Muttaqin et al. (2022) identified school quality and ethnic diversity as factors associated with achievement disparities in Indonesia. The present study extends this discussion by comparing learning outcomes in two contrasting geographical environments within Papua. Rather than interpreting the lower scores in Nduga as evidence of lower learning capacity, the results highlight the need to consider the educational conditions under which teachers and students develop their competencies. Geographic isolation, accessibility, and differences in learning resources provide important contextual considerations, although their individual contributions to the observed score differences cannot be established from the descriptive analysis alone.

Comparable Student Gains Despite Unequal Final Achievement

The most notable finding is the difference between student learning gains and final achievement. The reported mean gain was 40.9 points in Nduga and 41.3 points in Jayapura, producing a difference of only 0.4 points. In contrast, the mean post-test scores differed by 11.1 points in favor of Jayapura. This pattern indicates that students in the two locations experienced broadly comparable score improvements during the GASING program, but their final levels of achievement remained unequal.

This distinction is important when evaluating educational equity. Similar gains do not necessarily indicate that students have reached equivalent levels of competence, particularly when their initial achievement differs. In this study, the substantial improvement among Nduga students suggests that learners in a remote highland setting can make meaningful progress during structured numeracy instruction. However, the remaining post-test gap indicates that short-term improvement alone may be insufficient to overcome differences in prior learning opportunities. Consequently, the contribution of GASING should be considered in terms of learning progress, while achievement convergence requires additional attention to the conditions that enable students to consolidate and extend their learning.

The findings are relevant to Nusantara et al. (2022), who examined the GASING mathematics approach in relation to numeracy skills in rural Papua. They support further consideration of GASING as an approach for strengthening foundational arithmetic competencies in underserved settings. Nevertheless, the present study does not establish that GASING alone caused the observed improvements because it did not include a control group or randomized assignment. The results therefore provide comparative evidence of improvement associated with program participation, rather than definitive evidence of causal effectiveness or proof that the method independently eliminates educational inequality.

Differences in Teacher Learning Gains

The teacher results reveal a different pattern from the student findings. Jayapura teachers recorded an average gain of 38.3 points, compared with 29.0 points in Nduga, representing a 9.3-point difference. Jayapura teachers also achieved higher post-test scores across all five assessed domains. These findings suggest that the two locations differed not only in teachers' final numeracy competencies but also in the magnitude of improvement observed during the training program.

One possible interpretation is that teachers' opportunities to benefit from professional development are shaped by their broader educational and institutional environments. Access to instructional resources, opportunities for continued practice, digital facilities, and professional support may influence how training content is learned and subsequently reinforced. However, these factors should be treated as plausible contextual explanations rather than demonstrated causes because the study did not test their independent relationships with teacher gain scores. The findings nevertheless indicate that providing the same general training approach may not be sufficient to produce comparable teacher learning outcomes across geographically unequal settings.

This interpretation is consistent with Mulyawati and Sarwinda (2021), who reported on GASING mathematics workshops for elementary school teachers, and Nursakiah and Bahar (2021), who examined training in the application of GASING to basic arithmetic operations. These studies establish the relevance of structured teacher training in developing familiarity with the method. The present findings add a geographical comparison by showing that teacher gains were not equivalent across the two research sites. Future implementation should therefore consider whether teachers in remote settings require additional guided practice, follow-up mentoring, and sustained opportunities to apply the method in classroom instruction. Such support is a practical implication of the observed disparity, although its effectiveness would need to be evaluated in subsequent research.

Differences Across Numeracy Domains

The domain-level findings show that regional disparities extended across the five assessed numeracy competencies rather than being confined to a single operation. Jayapura teachers achieved post-test scores ranging from 75 to 84, whereas Nduga teachers scored

between 47 and 70. Among students, Jayapura scores ranged from 47 to 75, compared with 39 to 60 in Nduga. These patterns indicate that the overall regional difference was reflected across foundational counting, addition, multiplication, subtraction, and division.

Division deserves particular attention because it represented the highest-scoring domain among teachers in both locations, with scores of 84 in Jayapura and 70 in Nduga, but remained a relatively weak area among students. Student division scores were 47 in Jayapura and were reported within the lower overall post-test range in Nduga. This contrast suggests that competency profiles differed between teachers and students and that progress in one participant group should not be assumed to represent equivalent mastery in the other. Instructional planning should consequently identify specific student learning difficulties rather than relying exclusively on overall mean scores.

The findings can be interpreted alongside Mainali's (2021) discussion of mathematical representation, which emphasizes the importance of using and connecting different representations to support mathematical understanding. Within the GASING approach, a gradual progression from concrete experiences toward symbolic and procedural understanding provides a relevant pedagogical rationale for teaching foundational arithmetic. However, the present study did not directly measure the use of mathematical representations or test whether particular instructional sequences accounted for the differences between domains. The relationship between these pedagogical principles and the observed score patterns should therefore be understood as an interpretation that warrants further investigation, rather than a mechanism demonstrated by the current data.

Geographic, Social, and Educational Dimensions of Disparity

The multidimensional analysis provides additional context for interpreting the achievement differences. The reported composite gap was largest in the spatial dimension, at 3.5 points, followed by the social dimension at 2.8 points and the educational dimension at 1.8 points. The spatial scores were 1.2 for Nduga and 4.7 for Jayapura, while the educational scores were 2.3 and 4.2, respectively. These results indicate that the contrast between the two research sites was not limited to assessment performance; it also appeared in the contextual profiles used to characterize their learning environments.

The relatively large spatial gap highlights the importance of accessibility and geographical conditions when planning educational interventions in Papua. The findings are consistent with Maharani (2021), who examined factors associated with school participation in Merauke Regency, and with Mollet (2021), whose work discusses education and development in the Papuan highlands. Together, these sources provide contextual support for examining educational outcomes in relation to the conditions surrounding schools and communities. However, the present study's composite scores describe differences between the selected sites and should not be interpreted as direct measurements of the causal effects of geography on numeracy achievement.

The social and educational gaps also indicate that spatial inequality should not be treated as a purely physical problem. Access to professional development, learning facilities, and educational support may interact with geographical constraints to shape the opportunities available to teachers and students. The smaller reported gap in teacher qualifications, at 0.5 points, further suggests that formal qualifications alone may not adequately represent differences in the learning environments of the two regions. Nevertheless, this interpretation requires caution because the composite indicators were analyzed descriptively, and the study did not estimate the independent effects of individual contextual factors. The results support a

multidimensional approach to educational planning, but they do not establish which specific factor contributes most strongly to the achievement gap.

Implications for Equitable Numeracy Development

The combined findings suggest that numeracy improvement and achievement equity should be treated as related but distinct educational objectives. The near-equivalent student gains demonstrate that substantial score improvements were observed in both Nduga and Jayapura, while the remaining post-test gap indicates that comparable progress did not produce comparable final achievement. For teachers, the larger difference in gains further indicates that the implementation of professional development requires attention to the specific needs of remote educational settings.

Accordingly, GASING implementation in geographically disadvantaged areas should be accompanied by continued learning opportunities, targeted support for difficult arithmetic operations, and monitoring of individual progress after training. The spatial and educational profiles also support attention to practical barriers involving transportation, infrastructure, connectivity, and access to instructional resources. These measures should complement rather than replace appropriate teaching strategies. This direction is consistent with UNESCO (2023), which emphasizes that educational technology and resources need to be considered in relation to the conditions under which they are accessed and used. In remote communities, interventions should therefore be designed around locally feasible forms of support instead of assuming that arrangements suitable for urban schools can be transferred without adaptation.

Several methodological limitations qualify these implications. The study used a non-randomized, one-group pre-test–post-test design, so the observed changes cannot be attributed exclusively to GASING. The training programs also took place in different periods, with Jayapura participating in November–December 2023 and Nduga in July–August 2024. Consequently, differences in training period and other unmeasured contextual conditions may have influenced the comparison. In addition, the descriptive analyses do not establish the statistical significance of the regional differences or the independent relationships between contextual indicators and achievement. These limitations mean that the findings should be interpreted as evidence of comparative learning patterns rather than definitive causal effects.

Future research should incorporate control or comparison groups, consistent assessment schedules, and follow-up measurements to examine whether improvements are sustained. Analyses of individual-level data would also help determine how initial competency, attendance, learning opportunities, and access to educational support relate to subsequent achievement. In addition, the study's reported participant counts and domain-level mastery percentages should be checked against the original dataset before publication to ensure consistency across the analyses. Such steps would strengthen the evidence for determining how GASING can be implemented effectively and equitably across Papua's diverse educational settings.

Overall, the principal contribution of this study is its distinction between comparable student learning gains and persistent regional achievement disparities. The findings suggest that structured numeracy instruction can be accompanied by substantial improvement in both remote highland and urban coastal settings, but improvement alone does not guarantee convergence in final competency levels. Addressing educational inequality therefore requires a combination of appropriate instructional approaches, sustained teacher support, and context-sensitive measures to improve learning opportunities in geographically disadvantaged communities.

CONCLUSION

This study concludes that numeracy learning outcomes following the implementation of the GASING method differed between Kabupaten Nduga and Kota Jayapura. The mean post-test scores were higher in Jayapura than in Nduga for both teachers (78.2 versus 57.0) and students (61.1 versus 50.1). However, the average student gain scores were nearly equivalent, at 41.3 points in Jayapura and 40.9 points in Nduga, whereas teacher gains differed by 9.3 points in favor of Jayapura. These findings indicate that comparable improvements in student numeracy can coexist with unequal final achievement. The multidimensional analysis also identified the largest contextual disparity in the spatial dimension (3.5 points), followed by the social dimension (2.8 points) and the educational dimension (1.8 points). Therefore, efforts to improve numeracy in Papua need to combine structured instructional approaches with sustained teacher support, improved educational accessibility, and learning resources suited to local conditions.

This study is limited by its non-randomized, one-group pre-test–post-test design, the different periods of GASING implementation, and the absence of follow-up assessments. Consequently, the observed improvements cannot be attributed exclusively to GASING, and the persistence of learning gains over time remains unknown. Future research should use comparison groups, consistent assessment schedules, and longitudinal measurements to examine learning retention and the factors associated with differences in achievement. Further analysis of individual-level data is also needed to clarify how initial competency, access to educational resources, and professional support relate to learning progress. In addition, participant counts and domain-level mastery percentages should be verified against the original dataset before publication. These steps would strengthen the evidence needed to develop numeracy interventions that address both learning improvement and persistent geographical disparities.

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