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Effectiveness of GASING Training on Elementary Teachers' Mathematics Competencies in Remote Indonesia

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ABSTRACT

Elementary school teachers in West Papua demonstrate critically low pedagogical competence in basic mathematics instruction, reflecting persistent educational disparities in eastern Indonesia. This study aims to measure the effectiveness of the Gampang, ASyik, and menyenaNGkan (GASING) method in improving teachers' competence in teaching basic arithmetic operations. It is hypothesized that the GASING training program will significantly improve teachers' pedagogical competencies across all five arithmetic domains, with larger gains among teachers with lower initial competencies. The research employed a quasi-experimental one-group pretest-posttest design with 40 elementary school teachers in South Manokwari who participated in an intensive three-week training (October 21 – November 8, 2025). The research instrument was a competency test measuring five domains: Bakal Kubagi concept, addition, multiplication, subtraction, and division. Data were analyzed using paired samples t-test with SPSS 27. The results showed significant improvements ($p<.001$) across all competency domains with very large effect sizes (Cohen's d ranging from 2.32 to 5.21). The mean total score increased from 15.87±16.73 to 79.80±12.31 (gain=63.93±12.98). Eighty percent of teachers achieved the high improvement category (gain>50). A strong negative correlation ($r=-.756$, $p<.001$) between initial scores and improvement indicates an equity-enhancing effect. The research concludes that the GASING method is highly effective as a teacher empowerment model in disadvantaged areas, with important implications for professional development policies based on innovative and contextual pedagogy.

1. Introduction

Educational inequality continues to represent one of the most pressing and structurally entrenched challenges in contemporary global education systems, particularly in geographically dispersed and socioeconomically heterogeneous nations such as Indonesia. Far from being a mere consequence of material scarcity, these disparities are increasingly understood as manifestations of deeper systemic imbalances involving teacher competence, pedagogical quality, and unequal access to sustained professional development. In peripheral regions, especially in eastern Indonesia, such inequalities are not only persistent but also cumulative, shaping long-term educational trajectories. Empirical evidence consistently demonstrates that rural and remote schools operate under significant constraints related to teacher quality, infrastructure limitations, and student achievement gaps when compared with urban counterparts (Sun & Rahman, 2024). These disparities are further intensified by asymmetrical policy implementation and uneven distribution of educational resources, which continue to marginalize remote regions within national development agendas (Delgado Vela, 2025).

Within this broader landscape, mathematics education occupies a foundational and strategic position, as early numeracy competence is closely linked to cognitive development, analytical reasoning, and long-term academic success. However, in disadvantaged contexts, mathematics instruction is frequently characterized by fragmented conceptual understanding, procedural rigidity, and limited pedagogical innovation. In regions such as South Manokwari, where the Human Development Index remains comparatively low, these challenges are

compounded by restricted access to professional development and limited institutional support systems (BPS Papua Barat, 2024). Consequently, strengthening teachers' pedagogical competence in mathematics becomes not merely a technical intervention but a systemic necessity for reducing educational inequality and improving learning outcomes.

In response to these challenges, the Indonesian government has introduced a range of policy interventions aimed at enhancing teacher professionalism and reducing disparities. The enactment of the Teacher and Lecturer Law, Undang-Undang No. 14 Tahun 2005, formally established teachers as professional practitioners, requiring academic qualifications, mastery of competencies, and certification as foundational standards (Efendi & Mashuri, 2021). Complementary initiatives such as the SM-3T program have been implemented to deploy graduate teachers to disadvantaged, frontier, and outermost regions, often integrated with the Teacher Professional Education program (PPG) (Febriana et al., 2018), Surya, 2016; Itasari, 2019). These initiatives reflect a strong policy commitment to addressing structural inequities in teacher distribution and competence.

Despite these efforts, a growing body of empirical research indicates that substantial challenges persist at the level of implementation. Remote schools continue to encounter infrastructural constraints, geographical isolation, and limited opportunities for supervision and professional learning (Febriana et al., 2018; Haris et al., 2018). Evaluations of programs such as SM-3T and PPG reveal issues related to coordination inefficiencies and limited program sustainability, which may reduce their overall impact (Friyatmi, 2018). Furthermore, national competency assessments suggest that a significant proportion of teachers remain below expected performance standards, raising questions about the effectiveness of certification processes (Efendi & Mashuri, 2021). These findings collectively highlight a critical gap between policy design and contextual realities, emphasizing the need for more adaptive, context-sensitive, and practice-oriented teacher empowerment strategies (Delgado Vela, 2025; Haris et al., 2018).

From a theoretical perspective, pedagogical competence is central to teacher professionalism, encompassing the capacity to design, implement, and evaluate meaningful learning experiences (Shulman, 1987). However, systematic reviews in teacher education reveal persistent disconnections between theoretical knowledge and classroom practice, particularly in culturally diverse and resource-constrained environments (Liao et al., 2022; McGraw et al., 2024; Abdraimova et al., 2025). Although recent studies have explored innovative professional development models and pedagogical approaches (Ataei et al., 2022; Baldwin et al., 2017; Wardat & AlAli, 2025; Haruna et al., 2025), there remains a notable lack of empirical research focusing on contextually grounded interventions that address initial competency disparities. Moreover, evidence suggests that professional development programs may inadvertently reinforce inequality when they fail to accommodate varying levels of prior knowledge (Bell et al., 2022; Knochel et al., 2022). Emerging perspectives, including trauma-informed and culturally responsive pedagogies, further underscore the importance of contextual adaptation in teacher learning (González, 2025; Knox, 2025; Krishnamoorthy et al., 2025).

In this context, the Gampang, ASyik, dan menyenaNGkan (GASING) method offers a distinctive and promising pedagogical approach. Developed by Yohanes Surya, GASING emphasizes conceptual clarity through simplification, engaging learning experiences, and the use of concrete manipulatives to support understanding (Surya, 2013; Surya & Moss, 2012). The method is deeply rooted in constructivist learning theory, particularly the concrete-visual-abstract progression, which aligns with foundational frameworks proposed by Piaget (1970) and Bruner (1966). This progression enables learners to construct meaning through multiple representational modes, facilitating deeper conceptual understanding. Previous studies have demonstrated the effectiveness of GASING in improving student mathematics achievement, reducing anxiety, and enhancing conceptual learning in remote Indonesian contexts (Surya, 2014; Prahmana & Surya, 2015; Shanty & Wijaya, 2012). However, its application as a structured model for teacher empowerment remains underexplored.

Addressing this gap, the present study investigates the effectiveness of GASING training in enhancing elementary school teachers' pedagogical competencies in South Manokwari. Specifically, the study evaluates improvements across five domains of basic arithmetic and examines patterns of competency gains in relation to initial teacher performance. The study is guided by the hypothesis that GASING training will significantly improve pedagogical competencies across all domains, with greater gains observed among teachers with lower initial competence. By integrating quantitative analysis with a context-sensitive intervention framework, this study contributes to the literature by offering empirical evidence on innovative teacher development models that are both effective and equitable.

The significance of this study lies in its potential to inform both theory and practice in teacher professional development. By demonstrating how a constructivist, intensive, and contextually adapted training model can generate substantial improvements in teacher competence, the study provides important insights for designing professional development

programs in disadvantaged settings. It also highlights the importance of aligning training approaches with local realities, emphasizing that effective teacher development requires not only content delivery but also meaningful engagement with contextual challenges. These findings are particularly relevant for educational systems seeking to balance quality improvement with equity considerations.

Ultimately, this study contributes to a broader reorientation of teacher professional development toward more inclusive, adaptive, and sustainable models. The findings suggest that interventions such as GASING have the potential to simultaneously enhance competence and reduce disparities, thereby addressing two critical dimensions of educational reform. In the context of educational practice, the study offers practical implications for policymakers, teacher educators, and institutions aiming to design scalable and context-responsive training programs. By foregrounding equity and effectiveness as complementary goals, the study provides a conceptual and empirical foundation for advancing professional development strategies that are capable of transforming educational outcomes in diverse and challenging environments.

2. Method

This study uses a quasi-experimental design with rigorous analysis, reliable validated instruments, bias-controlled data collection, and multi-layered statistics to assess effectiveness and equity. The framework emphasizes internal validity, reproducibility, and relevance in resource-constrained educational settings.

2.1 Research Design

This study employed a quasi-experimental one-group pretest-posttest design (Campbell & Stanley, 1963), selected due to the logistical and contextual constraints of conducting research in geographically isolated areas. The limited availability of qualified teachers and the impracticality of random assignment restricted the use of control groups. Although this design is susceptible to internal validity threats such as history, maturation, and testing effects (Shadish et al., 2002), it remains appropriate for measuring longitudinal changes within intervention-based educational studies in constrained environments. To enhance methodological rigor, the study implemented standardized instruments, controlled testing conditions, independent administration, blind dual scoring, and advanced statistical techniques including effect size estimation, Bonferroni correction, and post-hoc power analysis.

2.2 Participants and Research Setting

The participants were 40 elementary school teachers from South Manokwari Regency, West Papua. Purposive sampling was applied based on criteria including at least two years of teaching experience, active roles in grades 1 to 6, full participation commitment, and informed consent. While ensuring relevance, this approach may introduce motivational bias, as more engaged teachers were more likely to participate. Participants varied in educational background and teaching experience, reflecting realistic conditions in disadvantaged regions. The study site was selected due to its low Human Development Index and limited access to professional development opportunities (BPS Papua Barat, 2024). Power analysis using G*Power 3.1 confirmed sufficient statistical power above .99 (Faul et al., 2009).

2.3 Intervention Procedure

The intervention was a structured GASING training program conducted over 15 working days, totaling 90 instructional hours. It integrated five components: theoretical grounding, practical workshops, peer teaching, micro-teaching with video feedback, and reflective lesson study. This design aligns with evidence-based principles of effective professional development, emphasizing sustained duration, active learning, and collaboration (Guskey, 2002; Desimone, 2009; Darling-Hammond et al., 2017). Training content covered five arithmetic domains and incorporated concrete, visual, and abstract instructional strategies rooted in constructivist pedagogy.

2.4 Instrumentation

Data were collected using the Basic Mathematics Pedagogical Competency Test (TKPMD), developed based on Shulman's (1987) pedagogical content knowledge framework and adapted to the GASING context. The instrument comprised 25 multiple-choice items and 5 essays assessing conceptual understanding, procedural explanation, and diagnostic ability of student misconceptions. Content validity was confirmed through expert evaluation (CVI = 0.89), and pilot testing showed high reliability (Cronbach's $\alpha = 0.91$). While it effectively measures pedagogical content knowledge, it does not directly assess classroom teaching performance, which is acknowledged as a limitation.

2.5 Data Collection Procedures

Data collection was conducted in three stages under controlled and standardized conditions. The pre-test was administered at the beginning of the training, followed by a mid-training assessment for four domains, and a final post-test for the Bakal Kubagi domain. All assessments were supervised by independent personnel to minimize observer bias. Scoring was conducted through blind dual evaluation, achieving high interrater reliability (Cohen's Kappa = 0.87) (George & Mallery, 2003). It is noted that differences in testing timelines across domains may affect comparability, potentially underestimating full intervention effects for mid-training measures.

2.6 Data Analysis Techniques

Data analysis was conducted using SPSS version 27 within a comprehensive statistical framework. Descriptive statistics summarized score distributions, the Shapiro-Wilk test assessed normality, and paired samples t-tests evaluated pre-post differences, supported by their robustness under moderate non-normality (Lumley et al., 2002). Effect sizes were calculated using Cohen's d with confidence intervals (Cohen, 1988), and normalized gain scores were computed based on Hake (1998). Additional analyses included Pearson correlation to examine equity effects, coefficient of variation for disparity analysis, and linear regression to model predictors of improvement. Statistical significance was set at $\alpha = 0.05$ with Bonferroni adjustment ($\alpha = 0.01$).

2.7 Ethical Considerations

The study received ethical approval from the Research Ethics Committee of Cenderawasih University (No. 045/UN20.F09/PN/2025). Ethical protocols included informed consent, confidentiality through anonymization, voluntary participation, and equitable access to training. All data were securely stored and accessed only by the research team.

3. Result

3.1 Descriptive Statistics and Competency Improvement

Table 1 presents the comprehensive descriptive statistics and inferential test results across all five competency domains. Prior to the intervention, teachers demonstrated very low baseline competencies, with mean pre-test scores ranging from 3.00 (Division) to 28.00 (Addition) on a 100-point scale. A domain-by-domain examination of pre-test scores reveals a hierarchy of initial competency: Addition yielded the highest baseline (M=28.00, SD=31.48), followed by Subtraction (M=20.75, SD=28.50), Multiplication (M=14.00, SD=20.36), Bakal Kubagi (M=13.62, SD=17.39), and Division (M=3.00, SD=6.48). The notably high standard deviations relative to means in the pre-test indicate extreme heterogeneity in initial competencies, with some teachers scoring near zero while others demonstrated moderate proficiency. This wide variability underscores the diverse starting points within the participant group and the challenge faced by the training program in addressing such disparate skill levels simultaneously.

Table 1. Pre-Test, Post-Test, and Gain Score Statistics Across Competency Domains

Category	Pre-Test M (SD)	Post-Test M (SD)	Gain M (SD)	N-gain	t	p	Cohen's d [95% CI]
Bakal Kubagi	13.62 (17.39)	73.50 (13.69)	59.88 (13.34)	0.69	28.36	<.001	4.49 [3.67, 5.31]
Addition	28.00 (31.48)	89.00 (14.46)	61.00 (26.29)	0.85	14.67	<.001	2.32 [1.76, 2.88]
Multiplication	14.00 (20.36)	74.50 (16.63)	60.50 (18.12)	0.70	21.11	<.001	3.34 [2.65, 4.03]
Subtraction	20.75 (28.50)	84.50 (14.13)	63.75 (24.87)	0.80	16.19	<.001	2.56 [1.97, 3.15]
Division	3.00 (6.48)	77.50 (16.13)	74.50 (14.32)	0.77	32.87	<.001	5.21 [4.23, 6.19]
Total	15.87 (16.73)	79.80 (12.31)	63.93 (12.98)	0.76	–	<.001	–

Note. N=40 for all domains. Paired samples t-test used for all domains (robust with N=40). Bonferroni-adjusted significance threshold: α=.01. N-gain calculated using Hake's (1998) formula: N-gain = (post - pre) / (100 - pre). All p-values remain significant after Bonferroni correction.

Following the intervention, dramatic improvements occurred across all domains with mean post-test scores ranging from 73.50 to 89.00 (good to excellent categories). A notable pattern emerged in the post-test standard deviations, which decreased substantially compared to pre-test values across all domains: Bakal Kubagi (from 17.39 to 13.69), Addition (from 31.48 to 14.46), Multiplication (from 20.36 to 16.63), Subtraction (from 28.50 to 14.13), and Division (from 6.48 to 16.13).

The only exception was Division, where the post-test SD was higher than the pre-test SD; however, this is attributable to the near-zero baseline (M=3.00) which produced minimal variance, whereas the post-test distribution reflected genuine individual differences in attained competency. The overall

pattern of decreasing standard deviations indicates competency convergence, suggesting that the GASING training not only elevated mean performance but also reduced the spread of scores, bringing teachers closer together in their competency levels. The gain scores demonstrated consistently high absolute improvement across all five domains. The highest absolute gain was observed in Division (M=74.50, SD=14.32), followed by Subtraction (M=63.75, SD=24.87), Addition (M=61.00, SD=26.29), Multiplication (M=60.50, SD=18.12), and Bakal Kubagi (M=59.88, SD=13.34). In aggregate, the mean total score increased from 15.87±16.73 to 79.80±12.31, yielding a gain score of 63.93±12.98. The N-gain scores ranged from 0.69 to 0.85, all falling in the high category (>0.7) according to Hake's (1998) criteria, with Addition showing the highest normalized gain (0.85).

The high N-gain for Addition is noteworthy because this domain also had the highest pre-test mean; the normalized gain formula adjusts for ceiling effects, and the high value suggests that even where teachers had some prior knowledge, the GASING training was able to push performance substantially closer to maximum. Figure 1 visualizes the consistent improvement pattern across all domains, with error bars demonstrating the decreased variability in post-test scores relative to pre-test scores.

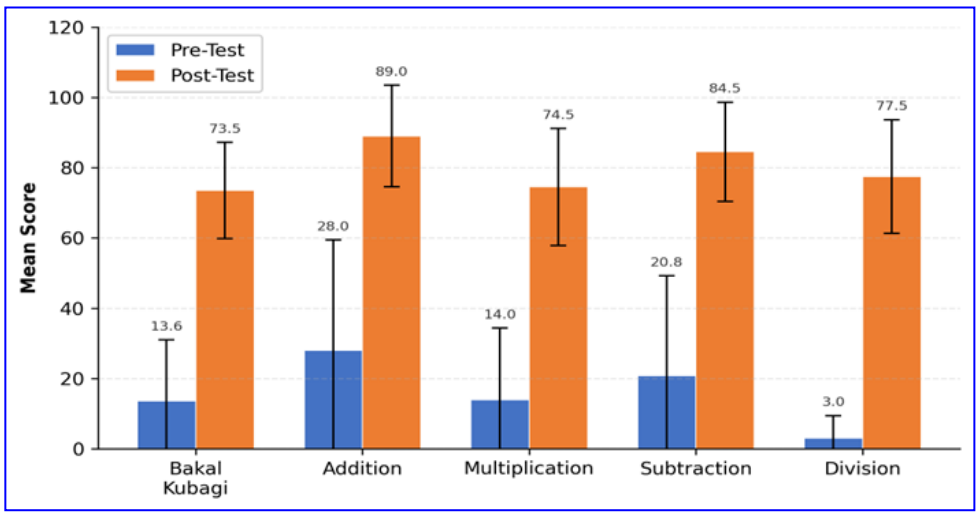


Figure 1. Pre-Test and Post-Test Scores Across Five Competency Domains

A closer examination of dispersion patterns further strengthens this interpretation. As reflected in both Table 1 and the error bars in Figure 1, standard deviations decrease across most domains after the intervention, indicating reduced variability in teacher

performance. This convergence suggests that the training not only improved overall competence but also aligned participants toward a more uniform level of mastery. The only domain showing increased variability is division, which can be interpreted as a natural expansion from a compressed near-zero baseline into a more differentiated distribution of achieved competence. The gain score analysis provides additional depth to this transformation. All domains exhibit substantial gains, with division showing the highest improvement, followed by subtraction, addition, multiplication, and Bakal Kubagi. The overall gain of 63.93 points reflects a large-scale shift in competency within a relatively short intervention period. Importantly, the normalized gain values consistently fall within the high category, indicating that the improvement is not only large in absolute terms but also efficient relative to initial performance levels.

A deeper analytical pattern emerges when linking baseline conditions to gain outcomes. Domains with lower initial scores tend to produce higher gains, suggesting that the intervention was particularly effective in addressing foundational knowledge gaps. At the same time, domains with relatively higher starting points, such as addition, still demonstrate strong normalized gains, indicating that the intervention successfully supported both remediation and advancement. This dual effect highlights the adaptability of the training model across varying competency levels

3.2 Normality Tests and Hypothesis Testing

The inferential analysis reveals two critical outcomes. First, although most gain score distributions deviate from normality, the statistical procedures remain robust and valid. Second, all competency domains exhibit highly significant and consistent improvements, with no cases of performance decline, confirming a uniformly positive intervention effect.

The Shapiro-Wilk normality test of gain scores demonstrated that only the Addition domain exhibited

normal distribution (W=0.948, p=.065), while four other domains demonstrated deviations from normality (Bakal Kubagi: W=0.918, p=.007; Multiplication: W=0.916, p=.006; Subtraction: W=0.938, p=.030; Division: W=0.885, p=.001). The non-normality in these four domains is likely attributable to the floor effect in pre-test scores, which produced positively skewed gain distributions as teachers with near-zero baselines showed large gains while those with moderately higher baselines showed comparatively smaller gains. However, given that the paired samples t-test is robust to moderate violations of normality when sample sizes approach or exceed 30 (Lumley et al., 2002), and given N=40 in this study, paired samples t-tests were employed for all five domains to maintain analytical consistency.

Results demonstrated that all domains experienced highly significant improvement (p<.001), with all p-values remaining significant even after Bonferroni correction for five comparisons (adjusted α=.01). The domain-by-domain paired t-test results were as follows: Bakal Kubagi, t(39)=28.36, p<.001, 95% CI for mean difference [55.62, 64.14]; Addition, t(39)=14.67, p<.001, 95% CI [53.60, 68.40]; Multiplication, t(39)=21.11, p<.001, 95% CI [54.70, 66.30]; Subtraction, t(39)=16.19, p<.001, 95% CI [55.80, 71.70]; and Division, t(39)=32.87, p<.001, 95% CI [69.92, 79.08].

The confidence intervals for all domains are entirely above zero and relatively narrow, indicating precise estimation of the treatment effect. Notably, the narrowest confidence interval was observed for Division (range of 9.16 points), reflecting the low variability in gain scores for this domain, while the widest was for Subtraction (range of 15.90 points), corresponding to the higher gain score variability. All domains showed 100% positive ranks, indicating that no teacher experienced competency decline—every single participant showed improvement following the training.

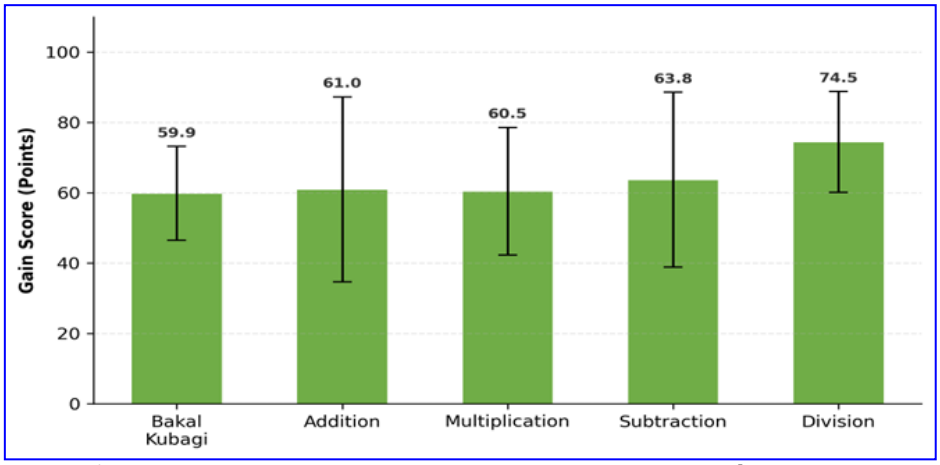


Figure 2. Gain Scores Across Five Competency Domains with Error Bars

As shown in Figure 2, all domains exhibit substantial gain values with relatively contained error margins, reinforcing the statistical results. The visual pattern confirms that improvements are not only significant but also consistently distributed across participants. The relatively small spread of error bars in several domains, particularly division and Bakal Kubagi, indicates stable and reliable gains, while slightly wider spreads in domains such as subtraction reflect natural variation without undermining the overall effectiveness.

Taken together, the statistical and visual evidence presents a compelling and cohesive narrative. The presence of non-normal distributions reflects the success of the intervention in transforming extremely low baseline scores into high post-intervention outcomes, rather than indicating analytical limitations. The uniformly significant test results, combined with entirely positive confidence intervals and visually consistent gain patterns, demonstrate that the intervention effect is both robust and universal. The absence of any negative change across participants further strengthens this conclusion, indicating that the training achieved complete directional consistency in improving teacher competence. Overall, the findings confirm that the observed improvements are statistically sound, practically meaningful, and systematically distributed, providing strong inferential support for the effectiveness of the intervention across all measured domains.

3.3 Intervention Effect Size

The effect size analysis reveals an exceptionally strong intervention impact across all competency domains. All effect sizes fall far beyond the conventional benchmark for large effects, indicating not only statistical significance but also substantial practical transformation in teacher competence. Importantly, the magnitude of these effects follows a systematic pattern linked to baseline conditions, highlighting the differential responsiveness of each domain.

Cohen's d calculations with 95% confidence intervals demonstrated very large effect sizes across all domains, far exceeding the conventional threshold of d=0.8 for large effect (Cohen, 1988). The Division domain demonstrated the largest effect size (d=5.21, 95% CI [4.23, 6.19]), followed by Bakal Kubagi (d=4.49, 95% CI [3.67, 5.31]), Multiplication (d=3.34, 95% CI [2.65, 4.03]), Subtraction (d=2.56, 95% CI [1.97, 3.15]), and Addition (d=2.32, 95% CI [1.76, 2.88]). Although Addition showed the lowest effect size, d=2.32 still reflects substantial change, nearly three times the conventional large effect benchmark. All lower bounds of the 95% confidence intervals exceeded 1.70, confirming that true population effects are consistently well above the large effect threshold.

An inverse relationship emerged between baseline scores and effect sizes, where lower pre-test means produced larger gains. Division (M=3.00, d=5.21) and Bakal Kubagi (M=13.62, d=4.49) showed the strongest effects, while Addition (M=28.00, d=2.32) was the lowest. This pattern reflects both statistical dynamics and a substantive finding that the GASING method is especially effective for topics with limited prior understanding, particularly in addressing conceptual difficulties.

These large effect sizes should be interpreted contextually. Their magnitude is influenced by low baseline scores, the intensive 90-hour training exceeding typical professional development duration, and alignment between the instrument and training content. Even so, the results indicate that GASING training produced meaningful improvements in teacher competency across all arithmetic domains.

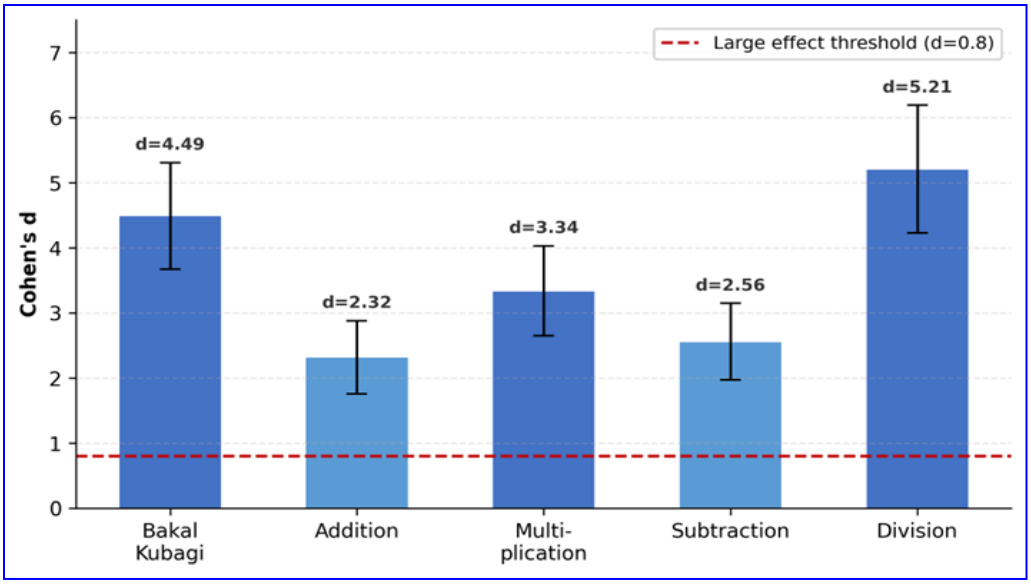


Figure 3. Effect Size (Cohen's d) with Large Effect Reference Line (d=0.8)

As illustrated in Figure 3, all effect sizes are positioned far above the reference line for a large effect, emphasizing the magnitude of change produced by the intervention. The clear separation between observed values and the threshold line visually reinforces the strength of the findings, indicating that the improvements are not marginal but represent substantial shifts in competence across all domains.

A deeper examination reveals a consistent inverse relationship between baseline scores and effect sizes. Domains with lower initial performance tend to exhibit larger effect sizes, with division and Bakal Kubagi representing the most extreme cases. In contrast, addition, which had the highest baseline score, shows the smallest effect size, although still within a very strong range. This pattern reflects both a statistical and substantive phenomenon. From a statistical perspective, lower baseline scores allow greater room for improvement. From a substantive perspective, the intervention appears particularly effective in addressing foundational conceptual gaps, where initial understanding is minimal.

This pattern suggests that the training model is highly responsive to areas of greatest need. Rather than producing uniform gains across all domains, the intervention demonstrates adaptive impact, delivering stronger effects in domains where conceptual deficiencies are most pronounced. This indicates a targeted pedagogical strength, where the instructional approach effectively reconstructs foundational understanding before advancing to higher levels of competence.

While the magnitude of the effect sizes is striking, it must be interpreted within the broader context of the intervention. Three interrelated factors contribute to the observed values. First, the extremely low baseline scores create a wide margin for improvement, naturally amplifying effect size calculations. Second, the intensity and duration of the

training, totaling 90 hours, exceed typical professional development formats, enabling deeper engagement and sustained learning. Third, the alignment between the training content and the assessment instrument ensures that the measured outcomes closely reflect the competencies targeted during the intervention.

Despite these contributing factors, the consistency of large effect sizes across all domains indicates that the observed improvements are not merely artifacts of measurement conditions but represent meaningful and substantive changes in teacher competence. The fact that all confidence intervals remain well above the large effect threshold further strengthens the robustness of these findings.

Overall, the combined statistical and visual evidence presented in Figure 3 confirms that the intervention achieved a high level of effectiveness across all competency domains. The effect size distribution not only demonstrates the strength of the intervention but also reveals its adaptive capacity to address varying levels of initial competence. This dual characteristic, strong overall impact and targeted responsiveness, underscores the transformative potential of the training model in improving teacher competencies in challenging educational contexts.

3.4 Disparity Analysis and Equity Effect

Disparity analysis using the coefficient of variation (CV) in total gain scores yielded a value of 20.30%, which falls in the moderate category (Kelley, 2007). This CV value indicates that although variability exists in competency improvement among teachers, the program remained relatively consistent in yielding improvement.

For comparison, CVs below 15% are generally considered low variability, 15–30% moderate, and above 30% high; the observed 20.30% thus suggests that the training produced reasonably uniform benefits without excessive disparity. Teacher categorization based on gain magnitude demonstrated a very positive distribution: 0% of teachers in the low category (gain<30), 20% in the medium category (gain 30–50), and 80% in the high category (gain>50).

The complete absence of teachers in the low improvement category is particularly noteworthy, as it indicates that even the least-improved participants still achieved meaningful gains of at least 30 points on the 100-point scale. Among the 8 teachers (20%) in the medium category, a preliminary examination of demographic characteristics suggests they tended to have longer teaching experience (>15 years) and non-education bachelor's degree backgrounds, though the small sub-group size precludes statistical testing of these associations. Figure 4 visualizes this distribution, demonstrating that the absolute majority of teachers achieved substantial improvement.

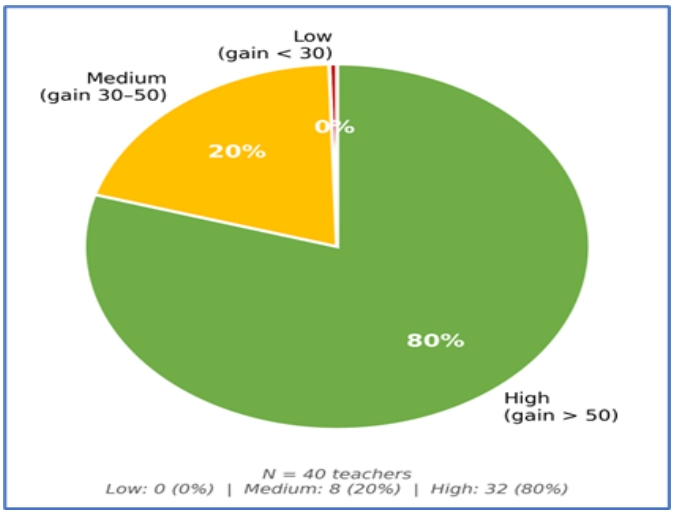


Figure 4. Distribution of Teacher Competency Improvement Categories

A critically important finding is the strong and significant negative correlation between pre-test scores and gain scores ($r=-.756$, $p<.001$, $r^2=.572$). This correlation indicates an equity-enhancing effect, where teachers with low initial competence actually obtained greater improvement compared to teachers with high initial competence. The correlation coefficient of -.756 represents a large effect according to Cohen's (1988) benchmarks (r>.50 = large), and the coefficient of determination ($r^2=.572$) indicates that initial competency level alone accounts for 57.2% of the variance in improvement scores. In practical terms, this means that teachers who entered the program with the lowest skills benefited the most, while those with relatively higher starting points—though still showing significant improvement—gained comparatively less.

Linear regression analysis yielded the predictive model: Gain = 89.65 – 1.62 × Pre-Test Score ($F(1,38)=50.43$, $p<.001$, $R^2=.572$). The regression constant of 89.65 suggests that a hypothetical teacher with a pre-test score of zero would be predicted to gain approximately 89.65 points, while the slope of -1.62 indicates that for every one-point increase in pre-test score, the predicted gain decreases by 1.62 points. This model explains 57.2% of gain score variance, indicating that initial scores serve as a strong predictor of improvement magnitude. The remaining 42.8% of unexplained variance likely reflects individual differences in learning aptitude, motivation, prior mathematical exposure, and engagement with the training activities. This equity-enhancing pattern is significant from a policy perspective because it demonstrates that the GASING method disproportionately benefits those who need it most, effectively closing rather than widening competency gaps among teachers.

As displayed in Figure 4, the dominance of the high improvement category visually confirms the effectiveness and consistency of the intervention. The absence of low-performing cases suggests that the training reached all participants, regardless of their initial competency levels. The relatively small proportion of teachers in the moderate category reflects natural variation rather than systemic inequality, indicating that the intervention maintained a strong baseline of effectiveness across the cohort.

Beyond distributional consistency, a more critical pattern emerges in the relationship between initial competence and improvement. The analysis reveals a strong negative correlation between pre-test scores and gain scores, indicating that participants with lower starting points achieved greater improvements. This relationship demonstrates a clear equity-enhancing effect, where the intervention functions as a compensatory mechanism rather than reinforcing existing disparities.

The strength of this relationship is substantial, with initial competence accounting for a large proportion of the variance in improvement outcomes. This indicates that baseline performance is a key predictor of how much participants benefit from the intervention. In practical terms, teachers who began with the weakest competencies experienced the most significant gains, while those with relatively higher initial skills still improved but at a comparatively lower magnitude.

This pattern is further supported by the regression model, which shows a negative slope between initial scores and gain outcomes. The model suggests that each incremental increase in baseline competence is associated with a proportional decrease in expected gain. At the same time, the high intercept value indicates that even participants starting from very low levels have the potential to achieve substantial improvement. The remaining unexplained variance reflects the influence of individual factors such as learning engagement, prior exposure, and motivation, which operate alongside baseline competence in shaping outcomes.

Taken together, the findings present a coherent narrative of both effectiveness and equity. The relatively moderate variability in gain scores, combined with the dominance of high improvement categories in Figure 4, demonstrates that the intervention produced broadly distributed benefits. More importantly, the pronounced inverse relationship between baseline competence and subsequent improvement indicates that the intervention functions not merely as a general enhancement strategy, but as an equalizing mechanism. Participants who initially demonstrated lower levels of competence experienced disproportionately greater gains, suggesting that the intervention effectively targets and supports those at the lower end of the performance spectrum. As a result, it contributes to a meaningful reduction in disparities by accelerating the progress of lower-performing individuals at a higher rate compared to their higher-performing counterparts.

This dual effect, consistent improvement and disparity reduction, highlights the intervention's capacity to function not only as a tool for skill enhancement but also as a mechanism for structural equalization. The results indicate that the training model is particularly effective in addressing foundational gaps, thereby narrowing competency differences and promoting a more balanced distribution of teacher performance.

4. Discussion

The findings provide compelling evidence that the GASING training generated exceptionally strong improvements in elementary teachers' pedagogical competencies across all arithmetic domains. The magnitude of change, reflected in very large effect sizes, high normalized gains, and universal improvement across participants, indicates that the intervention achieved both depth and consistency of learning outcomes. More critically, the results reveal a pronounced equity-enhancing effect, where teachers with the lowest initial competencies experienced the greatest gains, thereby reducing pre-existing disparities. This dual impact, combining effectiveness with equity, positions the GASING method as a transformative and inclusive professional development model for disadvantaged educational contexts.

The magnitude of the observed improvements substantially exceeds those typically reported in the literature on teacher professional development, where effect sizes commonly fall within moderate ranges (Yoon et al., 2007; Aréchiga Cervantes et al., 2024;

Samudre et al., 2024). This divergence indicates that the intervention does not merely produce incremental gains but reflects a profound transformation in teachers' pedagogical competence. Such a level of impact suggests that the GASING training operates at a deeper cognitive and instructional level than conventional professional development models.

Rather than focusing on procedural or surface-level skill acquisition, the intervention appears to facilitate restructuring of teachers' pedagogical content knowledge, aligning with theoretical perspectives that conceptualize teacher learning as a process of conceptual change, cognitive reorganization, and professional identity development (Desimone, 2009; Darling-Hammond et al., 2017). In this sense, the findings contribute to an emerging body of research that positions effective professional development as transformative rather than additive.

This transformative effect can be theoretically explained through the strong alignment between the GASING method and constructivist learning theory. Constructivism posits that knowledge is actively constructed through experience rather than passively received, requiring learners to engage in processes of meaning-making, reflection, and conceptual reorganization (Piaget, 1970; Bruner, 1966). The GASING approach operationalizes these principles by structuring instruction through a progression from concrete to visual and abstract representations. This progression not only supports conceptual understanding but also reduces intrinsic cognitive load, thereby facilitating schema construction and long-term retention (Sweller et al., 2011).

In contexts such as West Papua, where teachers may have historically relied on procedural instruction without strong conceptual foundations, such an approach becomes particularly critical. It enables teachers to reconstruct their understanding from the ground up, addressing persistent misconceptions that may have been reinforced over years of practice. Moreover, the effectiveness of this approach can be further understood through its compatibility with sociocultural perspectives on learning, which emphasize the role of interaction, mediation, and contextual relevance in knowledge construction.

The GASING method, with its emphasis on collaborative learning, guided practice, and contextualized examples, creates opportunities for teachers to engage in socially mediated learning processes. These processes are particularly important in resource-constrained environments, where access to diverse learning experiences may be limited. In such contexts, professional development must not only deliver content but also create environments that support collective meaning-making and shared professional growth (Liao et al., 2022; Abdraimova et al., 2025).

The training design further amplifies these theoretical strengths through its intensity, coherence, and practice-oriented structure. The 90-hour duration of the program represents a significant departure from conventional short-term workshops, which have been widely criticized for their limited impact and lack of sustainability (Guskey, 2002; Desimone, 2009). Research consistently demonstrates that short-duration training often fails to produce meaningful changes in teacher practice because it does not provide sufficient time for deep learning, reflection, and application. In contrast, the extended duration of the GASING training allows for iterative cycles of learning, practice, feedback, and reflection, which are essential for internalizing new pedagogical approaches (Darling-Hammond et al., 2017).

The integration of multiple components, including theoretical instruction, hands-on activities, peer teaching, micro-teaching with feedback, and reflective lesson study, further enhances the effectiveness of the training. Each of these components plays a distinct role in the learning process. Hands-on activities enable teachers to experience mathematical concepts directly, fostering deeper understanding. Peer teaching and micro-teaching provide opportunities for practice and feedback, allowing teachers to refine their instructional strategies. Reflective lesson study encourages critical reflection and professional dialogue, supporting continuous improvement (Schön, 1983). Together, these elements create a comprehensive learning environment that supports both cognitive and professional development.

Another critical factor contributing to the effectiveness of the intervention is the strong alignment between training content and assessment. Coherence between what is taught and what is measured ensures that learning outcomes accurately reflect the competencies targeted during the training. This alignment enhances the validity of the findings and facilitates transfer of learning into practice (Baldwin et al., 2017; Ataei et al., 2022). In many professional development programs, a lack of alignment between training content and evaluation criteria undermines the effectiveness of the intervention, as teachers may not perceive a clear connection between learning activities and expected outcomes. The GASING training avoids this issue by maintaining a high degree of coherence throughout the program.

A particularly significant contribution of this study lies in the identification of a strong equity-enhancing effect. The negative relationship between initial competence and improvement indicates that the intervention functions as a compensatory mechanism, disproportionately benefiting teachers with lower starting points. This finding is especially important in light of previous research suggesting that professional development may reinforce existing inequalities by benefiting already high-performing teachers (Wayne

et al., 2008). The results of this study challenge this assumption and demonstrate that, when designed appropriately, professional development can actively reduce disparities.

The accessibility of the GASING approach plays a central role in this equity-enhancing effect. By simplifying complex concepts, using visual representations, and incorporating engaging learning activities, the method reduces barriers associated with mathematics anxiety and limited prior knowledge (Surya, 2013; Surya & Moss, 2012). This aligns with equity-oriented pedagogical frameworks that emphasize the importance of differentiated scaffolding and inclusive instructional design (Bell et al., 2022; Knochel et al., 2022). Furthermore, the collaborative nature of the training creates opportunities for peer support and knowledge sharing, which can further enhance learning outcomes for lower-performing participants. These findings support the notion that equity in education is not merely about providing equal opportunities but about designing interventions that address the specific needs of disadvantaged learners.

The domain-specific findings provide additional insight into the mechanisms underlying the observed improvements. The exceptionally large effects observed in domains such as division and Bakal Kubagi suggest that the intervention is particularly effective in addressing areas characterized by deep conceptual gaps. While part of this pattern can be attributed to statistical factors, such as low baseline scores and greater room for improvement, it also reflects the substantive effectiveness of the GASING method in reconstructing foundational understanding. Previous research has demonstrated that manipulative-based and concrete instructional approaches can significantly improve conceptual learning in mathematics, particularly in contexts where traditional instruction emphasizes rote procedures (Surya, 2014; Prahmana & Surya, 2015; Shanty & Wijaya, 2012; Haruna et al., 2025). The present study extends these findings by showing that such approaches can also be highly effective in improving teacher competence, thereby enhancing the overall quality of instruction.

When viewed within the broader context of global teacher development research, the findings of this study both confirm and extend existing evidence. Studies conducted in rural and developing regions have reported positive impacts of teacher training on instructional quality, although these impacts are typically more modest in magnitude (Sun & Rahman, 2024). Similarly, research on culturally responsive and equity-oriented professional development highlights the importance of context-sensitive approaches that take into account the specific needs and challenges of different educational settings (Liao et al., 2022; Pierson et al., 2024; Abdraimova et al., 2025).

This study contributes to the literature by showing that combining constructivist pedagogy, intensive training, and contextual adaptation yields not only strong average gains but also reduced disparities. It reinforces that effective professional development should move beyond standardized models toward adaptive, contextually grounded approaches (Delgado Vela, 2025).

From a policy perspective, the implications of these findings are significant. First, the results highlight the limitations of short-term, fragmented professional development programs and support a shift toward sustained, practice-based models (Guskey, 2002; Desimone, 2009; Darling-Hammond et al., 2017). Second, the equity-enhancing effect underscores the importance of prioritizing professional development in disadvantaged regions, where the potential for impact is greatest. Third, the structured and replicable nature of the GASING training provides a practical framework for scaling up teacher development initiatives. Integrating such approaches into pre-service teacher education programs could further enhance their impact by ensuring that future teachers are equipped with strong pedagogical foundations from the outset.

Despite these strengths, the findings must be interpreted in light of several methodological limitations. The absence of a control group introduces potential confounding factors, including testing effects, Hawthorne effects, and regression to the mean (Campbell & Stanley, 1963; Shadish et al., 2002). In addition, while the study demonstrates substantial improvements in pedagogical content knowledge, it does not directly assess changes in classroom practice or student learning outcomes. This limitation is important, as research consistently shows that improvements in teacher knowledge do not automatically translate into improved instructional practice without ongoing support and contextual alignment (Guskey, 2002; Desimone, 2009).

Future research should address these limitations by employing more rigorous experimental designs, including randomized controlled trials, to strengthen causal inference. Longitudinal studies are also needed to examine the sustainability of the observed improvements and their impact on student learning outcomes. In addition, mixed-method approaches that combine quantitative and qualitative data could provide deeper insight into the mechanisms underlying the effectiveness of the intervention, including how teachers experience and internalize the GASING approach. Further research should also explore the adaptability of the model across different subjects and contexts, as well as the role of contextual factors such as institutional support, teacher motivation, and community engagement in shaping outcomes.

5. Conclusions

This study provides robust empirical evidence that the GASING training model produces substantial and transformative improvements in elementary teachers' mathematical pedagogical competence in remote and disadvantaged contexts. The findings demonstrate not only exceptionally large gains across all competency domains but also a consistent reduction in performance disparities, indicating that the intervention functions simultaneously as a performance accelerator and an equity-enhancing mechanism. By integrating constructivist pedagogy, intensive training duration, and contextually grounded instructional design, the GASING approach moves beyond conventional professional development models and offers a more adaptive, inclusive, and impactful framework for teacher learning.

The novelty of this study lies in its demonstration that high-intensity, structured, and conceptually scaffolded training can generate both high effectiveness and equitable outcomes, particularly benefiting teachers with the lowest initial competencies. These results carry significant implications for educational policy and practice, emphasizing the need to shift from fragmented, short-term training toward sustained, practice-based professional development programs that prioritize disadvantaged regions and promote inclusive pedagogical transformation.

At a broader level, the study contributes to the ongoing discourse on equity in education by providing empirical support for intervention models that actively reduce competency gaps rather than reinforce them. Nevertheless, future research is required to strengthen causal inference through experimental designs, to examine the long-term sustainability of competency gains, and to explore the translation of teacher learning into classroom practice and student outcomes. Expanding the application of the GASING model across different subjects, educational levels, and cultural contexts will further enhance its potential as a scalable and transformative solution for improving educational quality in diverse settings.

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