



Contents lists available at Journal Global EConedu

Journal of Educational and Learning Studies

ISSN: 2655-2760 (Print) ISSN: 2655-2779 (Electronic)

Journal homepage: <http://jurnal.globaleconedu.org/index.php/jels>



The effectiveness of the GASING method, based on a realistic mathematics education approach, on elementary school students' mathematical self-confidence

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Article Info

Article history:

Received Aug 26th, 2026

Revised Sep 30th, 2026

Accepted Oct 21th, 2026

Keyword:

Gasing,
Realistic mathematics education,
Mathematical self-confidence

ABSTRACT

Mathematical self-confidence is an important affective aspect of mathematics learning in elementary school because it is related to students' confidence in understanding concepts, solving problems, communicating strategies, and overcoming various difficulties. However, a learning process that remains focused on procedures and routine drills can limit students' engagement and their belief in their mathematical abilities. Combining the GASING Method (Easy, Fun, and Enjoyable) with the Realistic Mathematics Education (RME) approach provides a learning experience that is concrete, gradual, contextual, and enjoyable. Objective: This study aims to analyze the effectiveness of the PMR-based GASING Method on elementary school students' mathematical self-confidence by comparing it with the Contextual Teaching and Learning (CTL)-based GASING Method. This study employs a quantitative approach using a quasi-experimental method and a Nonequivalent Control Group design with a pretest-posttest pattern. The study sample consisted of 96 fourth-grade elementary school students in Buton Regency, comprising 48 students in the experimental group and 48 students in the control group. Data collection was conducted using a Likert-scale questionnaire on mathematical self-confidence, while data analysis included descriptive statistics, prerequisite tests, ANCOVA, and effect size. The mean mathematical self-confidence score for the experimental group increased from 52.80 to 75.06, while that of the control group increased from 39.62 to 61.13. The ANCOVA analysis revealed a significant difference between the two groups after controlling for pretest scores, $F(1,93) = 65.403$, $p < 0.001$. The adjusted mean for the experimental group was 74.61 and for the control group was 61.58, with a partial eta-squared of 0.413. Conclusion: The PMR-based GASING method has proven effective in developing elementary school students' mathematical self-confidence and in expanding the application of GASING not only to mathematical abilities but also to the affective aspects of mathematics learning.



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Introduction

Mathematics at the elementary school level is not only focused on mastering concepts, facts, and procedural skills, but also on developing positive dispositions, one of which is mathematical self-confidence. Mathematical self-confidence refers to students' belief in their own ability to understand concepts, solve problems, provide

answers, propose strategies, and cope with difficulties while learning mathematics (Siregar, 2021). This affective aspect is important because learning success is determined not only by cognitive abilities but also by how students perceive their own abilities and respond to mathematical demands. Students with high mathematical self-efficacy tend to be more willing to try, express ideas, stick to strategies, and evaluate their mistakes. Conversely, low self-efficacy can lead to doubt, avoidance of challenges, dependence on teachers or peers, and low engagement in mathematical activities. A longitudinal study of 2,789 elementary school students revealed a reciprocal relationship between mathematical self-efficacy, math anxiety, interest, and math achievement, while experiences of success were associated with improvements in learning outcomes (Caviola et al., 2022; Putra et al., 2025). A study of 219,826 responses from students aged 6–16 also found a positive correlation between self-confidence and success in answering math questions, with variations based on age, gender, and socioeconomic status (Foster et al., 2022; Rafiki et al., 2025). Therefore, mathematical self-confidence needs to be systematically developed starting in elementary school.

This issue becomes even more complex when mathematics instruction is still dominated by the presentation of procedures, routine exercises, direct examples, and the transfer of knowledge from teacher to student. This approach can lead to mathematics being perceived as abstract, difficult, and prone to errors especially when instruction emphasizes correct answers over the thinking process, the exploration of strategies, and the courage to try. Conversely, learning experiences that provide opportunities for gradual success, discussion, receiving feedback, and solving problems relevant to students' lives can support the development of self-efficacy. (Du et al., 2021) demonstrated a correlation between mathematics self-efficacy, math anxiety, and math achievement, whereas Rozgonjuk et al. (2020) found a strong negative relationship between math anxiety and mathematics self-efficacy. In the Indonesian context, Ningrum (2023) demonstrated that Realistic Mathematics Education (RME) is associated with improved mathematical understanding and increased self-confidence among elementary school students. These findings suggest that meaningful context-based learning has the potential to provide positive academic experiences while supporting affective development.

One relevant approach is Realistic Mathematics Education (RME), which in the Indonesian context is known as the Realistic Mathematics Approach (PMR). RME uses meaningful situations closely tied to students' experiences as the starting point for learning through mathematization, exploration, representation, discussion, argumentation, and reflection. Thus, mathematics is understood as knowledge that can be used to solve real-life problems, not merely a collection of formulas and procedures. An analysis of RME publications in elementary schools from 2013 to 2022 identified 265 articles in accredited journals and Scopus-indexed journals, indicating a high level of academic interest in this approach (Karimah et al., 2024; Kurnaedi et al., 2024). A bibliometric study covering the period 1990–2024 also shows an increase in RME research since 2015 and identifies Indonesia as one of the centers of RME research productivity in elementary schools (Fajri et al., 2025). Empirically, RME is associated with student learning outcomes, motivation, understanding, problem-solving, and self-confidence (Sancu, 2023; Sucahyo et al., 2021).

Nevertheless, much of the research on RME still focuses on learning outcomes, conceptual understanding, reasoning, problem-solving, numeracy, or self-efficacy. Siregar & Prabawanto, (2021) demonstrated that RME can enhance self-efficacy through a quasi-experimental design, though the study participants were middle school students. Basuki & Wijaya (2018) also found RME to be effective in enhancing self-efficacy in a high school context. At the elementary school level, (Sucahyo et al., 2021) tested RME on mathematical understanding and self-confidence but did not integrate it with the GASING Method. On the other hand, GASING (Easy, Fun, and Enjoyable) has begun to emerge as an alternative approach to mathematics learning that is concrete, systematic, step-by-step, and enjoyable. Adam et al., (2026) tested a dice-game-based GASING approach to improve elementary school students' multiplication skills, while Kambu et al., (2026) examined the effectiveness of GASING on elementary school students' numeracy skills. A systematic review by (Wenno et al., 2026). Shows that GASING emphasizes concrete, structured, visual, and enjoyable learning. However, research on GASING still primarily focuses on measuring arithmetic skills, numeracy, conceptual understanding, and learning outcomes, while mathematical self-confidence has not yet become a primary affective outcome.

The state-of-the-art of this research lies in the integration of GASING and PMR as two complementary learning approaches. GASING provides concrete, step-by-step, accessible, engaging, and enjoyable learning experiences, whereas PMR presents real-life contexts as the foundation for concept construction. The integration of both allows students to experience success, try various strategies, engage in discussions, communicate their thoughts, and reflect on the learning process. This approach aligns with the research by (Wisata et al., 2025), which integrated RME with computational thinking and demonstrated improvements in problem-solving and the role of self-efficacy, as well as the research by (Yuanita et al., 2025), which combined cultural contexts with RME to develop problem-solving skills and self-efficacy. Thus, the novelty of this study lies in the pedagogical

integration of GASING PMR with a specific focus on elementary school students' mathematical self-confidence through a quasi-experimental design.

Based on these empirical and research gaps, this study aims to analyze the effectiveness of the GASING Method based on the Realistic Mathematics Education (RME) approach on elementary school students' mathematical self-confidence. The study compares changes in mathematical self-confidence between a group that received GASING based on the Realistic Mathematics Approach and a control group that received GASING based on the contextual approach. This study is expected to expand the study of mathematics learning through empirical evidence regarding the integration of concrete experiences, realistic contexts, mathematical activities, and experiences of success in the development of students' affective aspects. Academically, the research findings can enrich the study of mathematics instruction that integrates cognitive and affective dimensions, while practically, they can serve as a guide for teachers in designing instruction that is concrete, contextual, systematic, enjoyable, and supportive of students' mathematical self-confidence.

Method

This study employed a quantitative approach using a quasi-experimental method to analyze the effectiveness of the GASING Method, based on the Realistic Mathematics Education (RME) approach, on the mathematical self-confidence of elementary school students. The design used was a Nonequivalent Control Group Design with a pretest–posttest pattern. This design was chosen because the research participants came from pre-existing classes, making full individual randomization impossible. Through this design, changes in mathematical self-confidence can be compared between the experimental and control groups while still accounting for students' initial conditions via the pretest. The nonequivalent control group design is appropriate for educational research when student placement follows existing class structures and individual randomization is difficult to achieve (Garcia, 2021)

The study involved two groups. The experimental group received instruction using the PMR-based GASING Method, while the control group received instruction using the Contextual Teaching and Learning (CTL)-based GASING Method. Both groups were assessed for mathematical self-confidence before and after the intervention. The research design is presented as follows:

Table 1. Research Design Presented

Group	Pretest	Treatment	Posttest
Experimental	Q ₁	X ₁ (PMR-based GASING)	Q ₂
Control	Q ₃	X ₂ (CTL-based GASING)	Q ₄

The use of a control group that also received GASING was intended to ensure that differences in outcomes could be attributed more to the characteristics of the learning approach rather than solely to the implementation of the GASING Method. Thus, both groups received the same basic learning method, while the learning approaches used differed. This strategy provided a more controlled comparison of changes in mathematical self-confidence. Previous research on RME among elementary school students also employed a quasi-experimental design with experimental and control groups to identify changes in learning outcomes following the intervention.

The study was conducted with fourth-grade elementary school students in Buton Regency. The population comprised all fourth-grade students at the schools designated as research sites, while the sample consisted of 96 students, divided into 48 students in the experimental group and 48 students in the control group. The sample was selected through purposive sampling, taking into account the equivalence of class characteristics, the number of students, learning conditions, and relatively comparable prior knowledge. This technique was chosen because the study utilized existing classes, making it impossible to randomly assign students individually without altering the learning structure.

Equivalence of baseline conditions was assessed using pretest results before the effectiveness analysis was conducted. Demographic characteristics, including gender, were also described to provide information on the composition of the participants. This step is crucial in quasi-experimental research because the absence of randomization may lead to differences in baseline conditions across groups. Therefore, pretest scores were used as covariates in an Analysis of Covariance (ANCOVA) to obtain estimates of posttest differences adjusted for students' baseline conditions.

The independent variable in this study is PMR-based GASING instruction, while the dependent variable is students' mathematical self-confidence. Operationally, mathematical self-confidence is defined as students' belief in their ability to understand and solve mathematical problems, their courage to provide answers, their

ability to express opinions or strategies, their readiness to face difficulties, and their ability to persevere in completing mathematical tasks.

Data were collected using a Likert-scale questionnaire developed based on indicators of mathematical self-confidence. Each statement had graded response options, ranging from “strongly disagree” to “strongly agree.” The scores for each item were summed to obtain an overall mathematical self-confidence score. Before being used in the main data collection, the instrument underwent content validation through expert judgment and empirical testing to ensure that each item represented the construct being measured. The use of self-confidence instruments in elementary school mathematics education has also been applied in RME research, including a study by (Sucahyo et al., 2021), which examined the relationship between realistic mathematics education and students’ self-confidence development.

The study was conducted in three phases: preparation, treatment, and evaluation. During the preparation phase, the researchers selected the sample, prepared the learning materials, developed and validated the instrument, and administered a pretest to both groups. The pretest aimed to obtain a baseline picture of students’ mathematical self-confidence while also providing covariate data for ANCOVA analysis.

The treatment phase was implemented according to the characteristics of each group’s intervention. The experimental group received PMR-based GASING instruction through concrete experiences, real-life contexts, exploration of various strategies, the process of mathematization, discussions, and gradual practice. The control group received CTL-based GASING instruction that emphasized the connection between the material and the students’ real-life contexts. The treatment was delivered over several sessions in accordance with the allocated mathematics instruction time. After the entire treatment was completed, both groups took a posttest using the same instrument or an equivalent form to assess changes in mathematical self-confidence. Previous applications of PMR in elementary school education have shown its potential to improve learning outcomes and affective aspects of mathematics, including students’ self-confidence.

Data analysis was conducted sequentially through descriptive analysis, assumption tests, ANCOVA, and effect size calculations. Descriptive analysis was used to describe the distribution of mathematical self-confidence scores in the experimental and control groups. The reported statistics included the mean, standard deviation, minimum, maximum, and changes in pretest–posttest scores. This stage provided an overview of the central tendency and variability of the data prior to inferential testing.

The testing of ANCOVA assumptions included normality, homogeneity of variances, linearity, and homogeneity of regression slopes. The normality test used the Shapiro–Wilk test, with data considered normal if $p > .05$. Homogeneity of variances was tested using Levene’s test, with $p > .05$ indicating no significant differences in variances across groups. Linearity was examined through the relationship between pretest and posttest scores, while the homogeneity of regression slopes was tested through the interaction between group and pretest. A non-significant interaction indicates that the regression slopes across groups can be considered homogeneous.

Hypothesis testing was conducted using ANCOVA, with posttest scores as the dependent variable, learning group as the independent variable, and pretest scores as the covariate. The ANCOVA model is formulated as follows:

$$Y_{post} = \beta_0 + \beta_1(Y_{pre}) + \beta_2(Group) + \varepsilon$$

Y_{post} represents the post-treatment mathematical self-confidence score, Y_{pre} represents the pre-treatment score, Group indicates the experimental or control group, and ε represents the error term. Group effects were determined based on the F-value, p-value, and adjusted mean. The null hypothesis was rejected if $p < .05$. The use of the pretest as a covariate allowed for a comparison of posttest scores across groups after controlling for variations in initial conditions.

In addition to statistical significance, the study calculates partial eta-squared (η^2) as a measure of effect size to determine the magnitude of the treatment effect after controlling for the influence of covariates. Reporting effect size is necessary because p-values indicate the presence of a statistical difference, whereas effect size provides information regarding the magnitude of the effect. The interpretation of η^2 follows general guidelines: 0.01 = small, 0.06 = moderate, and 0.14 = large, while taking into account the study design, sample characteristics, and field of research. All analyses were conducted at a significance level of $\alpha = .05$ using relevant statistical software. A combination of descriptive analysis, assumption tests, ANCOVA, and effect size was used to assess both the differences and the magnitude of the effect of PMR-based GASING on students’ mathematical self-confidence.

Results and Discussions

Descriptive Statistics

Descriptive statistical analysis was conducted to present an overview of the pretest and posttest scores, as well as changes in students' mathematical self-confidence scores in the experimental and control groups.

Table 2. Descriptive Statistics for the Pretest and Posttest

Group	N	Pretest Min	Pretest Max	Pretest Mean	SD	Posttest Min	Posttest Max	Posttest Mean	SD
Experimental	48	29,69	71,88	52,80	8,47	60,94	92,77	75,06	6,19
Control	48	12,50	59,38	39,62	9,47	50,00	76,56	61,13	6,48
Total	96	12,50	71,88	46,21	10,99	50,00	92,77	68,10	9,13

Source: SPSS 2026 Data

Based on Table 2, the control group's score increased by 21.52 points. The difference in increase of 0.74 points indicates that the raw gains of the two groups were relatively similar. Therefore, the magnitude of the increase, as described, cannot yet be used as the sole basis for determining the effectiveness of the treatment. Further analysis using ANCOVA with pretest scores as a covariate is necessary to control for differences in initial scores and produce a more controlled comparison of final scores between groups.

The increase in mathematical self-efficacy found in this study is generally consistent with research findings showing a relationship between students' belief in their mathematical abilities and their engagement and learning outcomes. Street et al., (2024) explain that mathematical self-efficacy can change during the learning process and is related to students' engagement and perseverance. Furthermore, Du et al., (2021), through a longitudinal study involving 2,789 elementary school students, found a reciprocal relationship between mathematical self-efficacy, math anxiety, and math achievement. Therefore, the changes in self-efficacy scores in this study can be viewed as part of the development of students' affective aspects that occur while they gain mathematical learning experiences.

Normality Test

Normality tests were conducted on the pretest and posttest scores, as well as the residuals of the ANCOVA model, using the Shapiro-Wilk test at a significance level of $\alpha = 0.05$.

Table 3. Results of the Shapiro-Wilk Normality Test

Group	Variabel	W-Statistic	Sig.	Conclusion
Experimental	Pretest	0,955	0,066	Normal
Experimental	Posttest	0,965	0,158	Normal
Control	Pretest	0,961	0,106	Normal
Control	Posttest	0,966	0,182	Normal
Residual ANCOVA	Residual	0,977	0,097	Normal

Source: SPSS 2026 Data

The test results show that all significance values are above 0.05. Thus, the pretest and posttest scores for the experimental and control groups, including the ANCOVA model residuals, can be said to satisfy the assumption of normality. The fulfillment of this assumption provides the basis for applying parametric analysis via ANCOVA.

Homogeneity Test

The Levene test was used to assess the equality of variances across groups prior to conducting the subsequent statistical analysis. This test was performed to determine whether the variability of scores was statistically comparable between the groups. A nonsignificant Levene test indicates that the assumption of homogeneity of variance is satisfied, whereas a significant result suggests that the variances differ significantly across groups. The results of the Levene test are presented in Table 4.

Table 4. Results of the Homogeneity of Variance Test

Variable	Levene's Statistic	Sig.	Conclusion
Pretest	1,050	0,308	Homogeneous
Posttest	0,140	0,709	Homogeneous

Source: SPSS 2026 data

The homogeneity test yielded significance values of 0.308 for the pretest and 0.709 for the posttest. Both values were greater than the predetermined significance level of 0.05, indicating that there was no statistically

significant difference in the variances of scores between the experimental and control groups at either measurement point. Therefore, the variability of students' scores can be considered sufficiently comparable across the two groups for both the initial and final measurements.

The result suggests that the distribution of scores within each group exhibited a similar degree of variability, meaning that one group did not demonstrate substantially greater score dispersion than the other. This condition is important because substantial differences in group variances may affect the reliability of between-group comparisons and complicate the interpretation of adjusted group effects. Since the obtained significance values exceeded 0.05 for both the pretest and posttest, the data did not provide evidence of a violation of the homogeneity of variance assumption.

The fulfillment of this assumption supports the subsequent use of ANCOVA to examine differences in posttest mathematical self-confidence between the experimental and control groups while accounting for the pretest score as a covariate. In this context, the comparable variance structure across groups provides a sound basis for estimating adjusted group differences and interpreting the ANCOVA results. Together with the other assumptions examined previously, the homogeneity test indicates that the data were sufficiently appropriate for the planned analysis.

Testing ANCOVA Assumptions

Another important assumption in ANCOVA is the homogeneity of regression slopes, which refers to the similarity of the relationship between the pretest covariate and the posttest dependent variable across all groups. This assumption is tested by including the interaction between group and pretest in the model.

Table 5. Test of Homogeneity of Regression Slopes

Source	F	df	Sig.
Group	66,648	1	<0,001
Pretest	0,901	1	0,345
Pretest × Group	2,771	1	0,099

Source: SPSS 2026 Data

The significant positive correlation between pretest and posttest scores ($r = 0.495$, $p < 0.001$) indicates a moderate positive association between students' initial mathematical performance and their subsequent achievement. In other words, students who entered the intervention with relatively stronger mathematical knowledge tended, on average, to obtain higher posttest scores. This pattern suggests that students' initial knowledge constituted an important component of their subsequent learning trajectory. The finding is theoretically meaningful because mathematics learning is cumulative and hierarchical: newly acquired concepts are often constructed upon previously established knowledge, procedures, and representations. Consequently, differences in students' initial understanding may continue to influence how effectively they process and integrate new mathematical information during instruction.

This interpretation is consistent with Alreshidi (2023), who demonstrated that enhancing topic-specific prior mathematical knowledge before introducing new content could improve students' subsequent mathematics achievement. His quasi-experimental study showed that prior mathematical knowledge was particularly relevant to students' conceptual and procedural learning, reinforcing the view that what students already know can influence how effectively they engage with subsequent mathematical content. Similarly, Stelzer et al. (2023) found that prior mathematics knowledge, including knowledge of fractions and division, significantly contributed to later mathematics achievement among primary school students. Their longitudinal analysis showed that specific mathematical knowledge explained a substantial proportion of the variance in subsequent achievement, although general cognitive abilities also contributed to students' performance. These findings provide additional support for interpreting the observed pretest–posttest correlation as an indication that students did not begin the intervention from an identical cognitive position.

The relationship between initial knowledge and later achievement is also supported by broader evidence. Breit et al. (2025), in a systematic review of meta-analyses involving mathematics achievement, identified prior knowledge as one of the variables most strongly associated with mathematics performance, alongside cognitive and skill-related factors. This evidence suggests that differences observed at the beginning of an instructional intervention should not be ignored when

comparing subsequent learning outcomes because baseline competence may contribute to the variation observed in students' posttest performance. In the context of the present study, the moderate correlation between pretest and posttest scores therefore indicates that the post-intervention scores reflect not only the instructional experience but also, to some extent, the students' initial level of mathematical understanding.

The finding also has implications for the interpretation of the GASING-based Realistic Mathematics Education approach examined in the present study. Because students entered the learning process with different levels of mathematical readiness, the effectiveness of an instructional intervention should ideally be evaluated while taking those initial differences into account. A student with a relatively high pretest score has a different starting point from a student whose foundational mathematical knowledge is limited. If these differences are not considered, a comparison based solely on posttest means may partially reflect pre-existing differences rather than differences associated with the instructional treatment. The use of baseline information therefore strengthens the analytical framework by distinguishing students' initial condition from their subsequent performance.

This principle is consistent with empirical studies that use pretest scores to statistically adjust posttest comparisons. Boström and Palm (2023), for example, employed ANCOVA to examine mathematics achievement after an instructional intervention, with pretest scores entered as a covariate. Their approach illustrates how ANCOVA can be used to estimate differences in posttest achievement after accounting for variation attributable to students' initial performance. Likewise, Alreshidi (2023) used pretest information to establish comparability between groups before examining differences in subsequent mathematics outcomes. Thus, incorporating baseline performance into the analysis is consistent with established practices in quasi-experimental mathematics education research.

Nevertheless, the significant correlation observed in the present study should not be interpreted as evidence that pretest performance *caused* posttest performance. Correlation describes the degree to which two variables vary together, but it does not by itself establish a causal relationship. The observed association may reflect several underlying mechanisms, including differences in prior knowledge, mathematical reasoning, learning readiness, or other learner characteristics. Recent research on prior mathematical knowledge similarly indicates that its predictive contribution may overlap with broader cognitive characteristics. Stelzer et al. (2023), for example, found that the predictive contribution of specific prior mathematical knowledge changed when working memory and fluid intelligence were included in the analytical model. This finding reinforces the importance of interpreting the present correlation as evidence of association rather than as an isolated causal mechanism.

From a methodological perspective, the significant pretest–posttest relationship provides a reasonable basis for considering the pretest as a potential covariate in an ANCOVA framework, provided that the relevant statistical assumptions are satisfied. In particular, ANCOVA is appropriate when the covariate is measured before the intervention, is theoretically related to the outcome, and has an approximately linear relationship with the dependent variable. The assumption of homogeneous regression slopes should also be examined to determine whether the relationship between pretest and posttest scores is comparable across instructional groups. Therefore, the present correlation result should be viewed as one component of the statistical justification rather than as the sole criterion for selecting ANCOVA.

The methodological relevance of controlling baseline performance is further illustrated by research using pretest and posttest designs in mathematics education. Boström and Palm (2023) explicitly described ANCOVA as a procedure for comparing posttest achievement between intervention and control groups while statistically controlling for differences in pretest performance. Similarly, Siller and Ahmad (2024) used a quasi-experimental framework to investigate mathematics achievement among elementary students receiving different forms of instructional support, highlighting the importance of considering students' existing mathematical conditions when evaluating instructional effectiveness. These studies reinforce the broader methodological principle that post-intervention differences are more meaningfully interpreted when students' initial levels of achievement are appropriately considered.

The present finding therefore strengthens the interpretation of the intervention results in two complementary ways. First, the significant positive correlation demonstrates that students' initial mathematical performance remained relevant to their subsequent achievement. Second, the result indicates the importance of considering baseline performance when estimating instructional effects, particularly in a quasi-experimental study in which students are drawn from existing classes rather than randomly assigned individually. Rather than treating pretest scores merely as descriptive information, the baseline measure can provide an analytical basis for understanding how students' initial readiness relates to subsequent learning.

Overall, the $r = 0.495$ correlation indicates that approximately 24.5% of the variance in posttest scores is linearly associated with pretest scores ($r^2 \approx 0.245$). This does not mean that 24.5% of students' learning was "caused" by their initial performance; rather, it indicates that students' baseline scores accounted for a meaningful proportion of the observed variation in posttest performance at the bivariate level. The remaining variation may be related to instructional exposure, students' engagement, classroom interaction, individual learning characteristics, measurement error, and other factors. Consequently, controlling for baseline achievement can provide a more refined estimate of the relationship between the instructional condition and posttest outcomes.

Taken together, the evidence suggests that students' initial mathematical competence should be treated as an important analytical consideration when evaluating the effectiveness of the GASING–Realistic Mathematics Education approach. The present correlation is consistent with contemporary mathematics education research showing that prior knowledge is associated with subsequent mathematical achievement (Alreshidi, 2023; Stelzer et al., 2023; Breit et al., 2025). At the same time, evidence from intervention studies demonstrates that pretest-adjusted analyses such as ANCOVA can be useful for estimating posttest differences while accounting for baseline variation (Boström & Palm, 2023). Therefore, the incorporation of pretest performance as a covariate is both theoretically defensible and methodologically appropriate provided that the required ANCOVA assumptions are demonstrated in the data. This approach allows the estimated instructional effect to be interpreted more carefully by separating, as far as statistically possible, differences attributable to students' starting levels from differences emerging after the learning intervention.

ANCOVA Results

An ANCOVA analysis was conducted with posttest self-confidence scores as the dependent variable, the experimental and control groups as fixed factors, and pretest self-confidence scores as a covariate. The analysis included 96 students.

Table 6. ANCOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	2.627,511	1	2.627,511	65,403	<0,001	0,413
Pretest	35,522	1	35,522	0,884	0,349	0,009
Error	3.736,199	93	40,174	–	–	–
Total	–	96	–	–	–	–

Source: SPSS 2026 Data

The results of the ANCOVA analysis revealed a statistically significant difference in posttest scores between the experimental and control groups after controlling for pretest scores, with $F(1, 93) = 65.403$ and $p < 0.001$. This finding indicates that the difference in students' mathematical self-confidence at the end of the intervention was significantly associated with the instructional treatment received by the two groups. After statistically adjusting for students' initial scores, the experimental group demonstrated a significantly different level of mathematical self-confidence compared with the control group. The magnitude of the F-value and the highly significant p-value provide strong statistical evidence that the observed difference in posttest scores was unlikely to have occurred by chance. Thus, the findings suggest that the instructional approach implemented in the experimental group contributed meaningfully to differences in students' mathematical self-confidence after the intervention.

In contrast, the pretest score, which was entered into the model as a covariate, did not have a statistically significant effect on posttest scores, with $F(1, 93) = 0.884$ and $p = 0.349$. This result indicates that, after accounting for the instructional group, differences in students' initial mathematical self-confidence did not independently explain a significant proportion of the variation in their post-intervention scores. The

nonsignificant effect of the covariate also suggests that the differences observed between the groups in the posttest were not substantially attributable to baseline scores. Therefore, the significant group effect provides stronger evidence that the instructional treatment, rather than students' initial levels of mathematical self-confidence, was associated with the differences in posttest outcomes.

The overall ANCOVA model yielded an R^2 of 0.557 and an Adjusted R^2 of 0.547. These values indicate that the model explained approximately 55.7% of the variance in students' posttest mathematical self-confidence, while the adjusted estimate indicated that approximately 54.7% of the variance remained explained after accounting for the number of predictors included in the model. This represents a substantial proportion of explained variance and indicates that the combination of instructional group and pretest scores provided considerable explanatory power for students' post-intervention mathematical self-confidence. The relatively small difference between R^2 and Adjusted R^2 further indicates that the explanatory capacity of the model remained stable after adjustment for model complexity.

Taken together, these findings demonstrate that group membership was the primary statistically significant predictor of posttest mathematical self-confidence in the ANCOVA model, whereas the pretest score did not make a significant independent contribution. The significant adjusted group effect, combined with the substantial proportion of explained variance, provides empirical support for the effectiveness of the instructional intervention in improving students' mathematical self-confidence. These results are particularly important because mathematical self-confidence represents an affective dimension of mathematics learning that may influence students' willingness to participate, engage with mathematical tasks, and persist when encountering difficulties. Accordingly, the findings suggest that the instructional treatment implemented in the experimental group was not only associated with differences in students' final scores but also accounted for a substantial proportion of the variability in mathematical self-confidence after the intervention.

Table 7. Adjusted Mean Posttest

Group	Adjusted Mean	SE	95% CI
Control	61,58	1,03	59,53–63,64
Experimental	74,61	1,03	72,56–76,66

Source: SPSS 2026 Data

The adjusted mean values were obtained after the posttest scores were adjusted for the pretest scores based on the overall covariate mean of 46.21. The adjustment results show that the adjusted mean for the experimental group was 74.61, while that for the control group was 61.58. Thus, there was a difference in adjusted means of 13.03 points. This difference indicates that the disparity in mathematical self-confidence between the groups remains evident even after controlling for variations in initial scores statistically.

The research results show that the application of the GASING Method based on the Realistic Mathematics Education (RME) approach is associated with differences in mathematical self-confidence scores between the experimental and control groups after controlling for initial scores. The primary evidence is not based solely on the increase in raw gains since the difference in gains between the two groups is relatively small but primarily on the ANCOVA results, which yielded $F(1,93) = 65.403$ with $p < 0.001$. These results indicate that differences in final scores between the groups remain significant even after accounting for variations in initial scores in the analytical model.

This difference in achievement is further evident in the adjusted mean scores. The experimental group achieved an adjusted mean of 74.61, while the control group achieved 61.58, resulting in a difference of 13.03 points. This means that when the groups are compared under the same covariate conditions, their levels of mathematical self-confidence show a fairly clear difference. The partial eta-squared value of 0.413 also indicates a substantial group effect size in the ANCOVA model. However, this value should be understood as a measure of the group factor's effect within the model, not as a direct percentage increase in students' confidence.

The results of this study are consistent with the findings of (Sucahyo et al., 2021), which demonstrated the influence of the Realistic Mathematics Education (RME) model on the self-confidence of elementary school students. That study involved fourth-grade students and showed that RME is related not only to mathematical understanding but also to self-confidence. These findings are relevant to the present study because PMR uses contextual situations as a crucial component in helping students build an understanding of mathematical concepts. Learning that stems from contexts students can understand provides them with opportunities to connect concrete experiences with the mathematical concepts being studied.

Support for these findings is also evident in the study by Ariffah & Rusnilawati, (2023). Using a quasi-experimental design, the study examined the implementation of RME supported by interactive multimedia and reported an effect on reasoning skills and self-confidence. Research by Wisata et al, (2025) also indicates that the

integration of RME with computational thinking is associated with elementary school students' mathematical problem-solving skills and self-efficacy. Thus, the findings of this study reinforce the view that the characteristics of realistic mathematics education not only have the potential to support cognitive development but also provide a learning environment relevant to the development of students' affective aspects.

From a psychological perspective, changes in mathematical self-confidence can be linked to the experiences of success students gain when facing and completing mathematical tasks. Street et al., (2024) explain that mathematical self-efficacy can develop and change during the learning process and is related to students' engagement, persistence, and performance. Du et al., (2021) also found a reciprocal relationship between self-efficacy, math anxiety, and math achievement among elementary school students. Therefore, learning that provides students with opportunities to understand problems through contexts closely related to their own experiences, to try out problem-solving strategies, and to gradually gain experiences of success has the potential to foster a more positive perception of their own mathematical abilities.

In the context of GASING implementation, the findings of this study are supported by a number of recent studies. Sariningsih et al., (2025) reported that the implementation of GASING combined with traditional games through a quasi-experimental design resulted in differences in mathematics learning outcomes compared to conventional instruction. Yusuf et al., (2026) also reported the effectiveness of a dice-based GASING approach in improving multiplication skills among elementary school students. Furthermore, Kambu et al., (2026) found an improvement in numeracy skills through the implementation of GASING, while Gesiradja et al., (2026) reported an improvement in basic arithmetic skills through the GASING program. A study by Samaudin et al., (2026) involving 96 fourth-grade students using the same design showed that PMR-based GASING yielded better results in critical thinking skills compared to the control group. Although these studies focused on cognitive achievement rather than mathematical self-confidence, their findings provide empirical evidence that GASING can create a structured, active, and student-engagement-oriented mathematics learning experience.

More specific findings are demonstrated by the study by Samaudin et al., (2026), which involved 96 fourth-grade students using a pretest-posttest nonequivalent control group design. The study employed PMR-based GASING in the experimental group and CTL-based GASING in the control group and found that PMR-based GASING was effective in enhancing students' critical thinking skills. The similarities in sample characteristics and treatments provide a relevant empirical context for this study, even though the dependent variables examined differ. This study expands on that research by focusing on mathematical self-confidence as the affective aspect being measured.

Overall, the results of the ANCOVA analysis support the research hypothesis regarding the existence of a difference in mathematical self-confidence scores between the experimental and control groups after controlling for pretest scores. The experimental group's performance is reflected in an adjusted mean of 74.61, while the control group's was 61.58, with a difference of 13.03 points. The partial eta-squared value of 0.413 indicates a substantial group effect size in the model. However, because this study used a quasi-experimental design with pre-existing classes, the results must be interpreted within the context of the study and should not be equated with causal evidence obtained through experiments involving individual randomization. Future research could expand the scope to include different schools, regions, and student characteristics, as well as consider the duration of the intervention and learning mechanisms that may play a role in the development of students' mathematical self-confidence.

Conclusions

Based on the research findings, the implementation of the GASING Method based on the Realistic Mathematics Education (RME) approach proved effective in improving the mathematical self-confidence of elementary school students. The experimental group showed an increase in average scores from 52.80 on the pretest to 75.06 on the posttest, while the control group showed an increase from 39.62 to 61.13. After controlling for pretest scores through ANCOVA analysis, a significant difference in posttest scores was found between the two groups, $F(1,93) = 65.403$, $p < 0.001$. The adjusted mean posttest score in the experimental group was 74.61, higher than that of the control group (61.58), with a difference of 13.03 points. The partial eta-squared value of 0.413 indicates that the group effect is substantial. Thus, the alternative hypothesis (H_a) is accepted and the null hypothesis (H_0) is rejected, indicating that PMR-based GASING has a significant effect on students' mathematical self-confidence compared to Contextual Teaching and Learning (CTL)-based GASING. The main contribution of this study lies in providing empirical evidence that the integration of GASING and PMR not only supports the implementation of mathematics instruction but also significantly enhances students' mathematical self-confidence. The findings of this study expand the application of GASING which was

previously more focused on developing mathematical skills by demonstrating its potential to simultaneously foster students' affective aspects. The implementation of PMR-based GASING also contributes to the development of learning that connects mathematical concepts to real-world contexts, encourages active student engagement, and provides students with opportunities to build confidence in their mathematical abilities. In practical terms, the results of this study provide an empirical basis for teachers to use PMR-based GASING as an alternative teaching method that can develop both students' mathematical abilities and their self-confidence. Thus, this study reinforces the finding that the integration of GASING and PMR is a relevant instructional strategy for supporting the development of cognitive and affective dimensions in mathematics learning in elementary school.

Acknowledgments

The authors would like to express their sincere gratitude to the elementary school, teachers, and students who participated in this study. Their willingness to participate in the learning activities and data collection process greatly contributed to the successful completion of the research. The authors also extend their appreciation to the teachers and school staff for their cooperation and support during the implementation of the GASING method integrated with the Realistic Mathematics Education approach. Finally, the authors are grateful to colleagues and other individuals who provided valuable assistance, feedback, and encouragement throughout the research process and the preparation of this manuscript.

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