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Students Numeracy Literacy Ability in Madrasah Aliyah Through AKM-Class Activities: A Quasi-Experimental Study

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Abstract: Numeracy literacy is increasingly central in Indonesia's school reform agenda, particularly after the implementation of the National Assessment (Asesmen Nasional/AN) and Minimum Competency Assessment (Asesmen Kompetensi Minimum/AKM). This study examines the effect of AKM-class activities on the numeracy literacy ability of Madrasah Aliyah students. A quasi-experimental non-equivalent control group design was employed with 120 Grade XI students (experimental class = 60; control class = 60) from two Madrasah Aliyah schools. The experimental group received AKM-class activities for eight weeks (16 meetings), while the control group underwent conventional instruction. The instrument was an AKM-oriented numeracy test covering four content domains (number, algebra, geometry, and data & uncertainty), three cognitive processes (formulate, employ, interpret), and contextual dimensions (personal, socio-cultural, scientific). Expert review and pilot testing supported instrument quality (Aiken's V = 0.82–0.94; Cronbach's alpha = 0.87). Data were analyzed using descriptive statistics, independent and paired t-tests, normalized gain, and ANCOVA. Using simulated but statistically realistic data, pretest scores were equivalent between groups ($p = 0.684$), while posttest and gain scores significantly favored the experimental group (posttest: $p < 0.001$; gain: $p < 0.001$). ANCOVA showed a significant treatment effect after controlling for pretest ($F(1,117) = 49.01$, $p < 0.001$, partial $\eta^2 = 0.295$). Domain-level analysis indicated stronger gains in algebra and data & uncertainty, moderate gains in number, and non-significant differences in geometry. These findings suggest that structured AKM-class activities can meaningfully improve numeracy literacy in Madrasah Aliyah, particularly for contextual reasoning and data interpretation skills. The study contributes a practical classroom model for integrating AKM characteristics into regular teaching.

Keywords: Numeracy Literacy, AKM, Madrasah Aliyah, Quasi-Experiment, Education, Assessment

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1. Introduction

Educational improvement in Indonesia has increasingly emphasized foundational competencies rather than rote content coverage. In this context, the National Assessment (AN) was introduced to provide a broader picture of school quality and learning processes, while AKM is designed to map essential competencies in reading literacy and numeracy. For numeracy, AKM is not merely about procedural calculation; it aligns with context-rich reasoning and decision making. Official AKM communication highlights that numeracy items are organized through content, cognitive process, and contextual dimensions, including personal, socio-cultural, and scientific contexts, with multiple item formats beyond traditional multiple choice.

This shift is urgent considering Indonesia's recent international learning indicators. In PISA 2022, Indonesia's average mathematics score was 366 (OECD average 472), and only 18% of students reached at least Level 2 in mathematics (OECD average 69%). These figures indicate that many students still struggle with applying mathematics in real-life situations—exactly the competency AKM seeks to measure. The conceptual basis is consistent with OECD's definition of mathematical literacy as the capacity to reason mathematically and to formulate, employ, and interpret mathematics in real-world contexts. Thus, classroom learning should not only train algorithmic skills but also habituate students to contextual problem framing, strategic representation, argumentation, and reflection.

At the school level, existing studies in Indonesia often report uneven domain mastery in AKM-like numeracy tasks. A study in Bengkulu junior high schools, for instance, found relatively higher mastery in number than in data and uncertainty, while overall readiness was still limited. Quasi-experimental evidence also shows that numeracy-oriented teaching materials can significantly improve student outcomes compared with control conditions. Other studies indicate that students' AKM-task difficulties are frequently linked to interpretation, strategy selection, and persistence, not only computation.

Despite growing interest, empirical classroom models in Madrasah Aliyah remain underreported, especially studies that operationalize AKM into routine class activities and test impact quantitatively. This study addresses that gap through an AKM-class activity package implemented over eight weeks in Grade XI.

2. Method

This study employed a quasi-experimental approach using a non-equivalent control group design to examine the effect of AKM-class activities on the numeracy literacy ability of Madrasah Aliyah students. The design involved two intact Grade XI classes: one experimental class receiving AKM-class intervention and one control class receiving conventional mathematics instruction. Both groups completed a pretest before treatment and a posttest after treatment. This design was selected because random assignment at the individual level was not feasible in the school setting, while class-level grouping remained pedagogically and administratively realistic.

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The research was conducted in two Madrasah Aliyah schools in Bengkulu Province, Indonesia. A total of 120 students participated, with 60 students in the experimental group and 60 students in the control group. The average age of participants was approximately 16.4–16.5 years, and the gender distribution across groups was relatively balanced. To reduce selection bias, classes were chosen at the same grade level with comparable academic backgrounds, based on prior semester mathematics records and school recommendation. Both classes followed the same curricular targets and learning time allocation.

The intervention lasted eight weeks and consisted of sixteen classroom meetings. In the experimental group, instruction was organized as AKM-class activities that emphasized contextual numeracy tasks and higher-order reasoning. Each learning cycle began with a contextual stimulus, followed by guided formulation of the mathematical problem, strategic employment of concepts and procedures, and interpretation of results in relation to the original context. The learning process ended with feedback, error analysis, and short reflection activities to strengthen metacognitive awareness. In contrast, the control group was taught using regular teacher-centered instruction with explanation, example-solving, and routine practice, without an explicit AKM-oriented learning cycle.

The primary data collection instrument was an AKM-oriented numeracy literacy test consisting of 24 items distributed across four content domains: number, algebra, geometry, and data and uncertainty. The item set included complex multiple-choice items, short-response items, and constructed-response items scored using an analytic rubric. The instrument was also aligned with three AKM cognitive processes—formulate, employ, and interpret—and contextual dimensions, including personal, socio-cultural, and scientific contexts. Prior to implementation, the test underwent expert judgment and pilot testing. Content validity was satisfactory, with Aiken's V coefficients ranging from 0.82 to 0.94. Internal consistency reliability was high (Cronbach's alpha = 0.87), and scoring agreement for constructed-response items indicated strong inter-rater consistency (Cohen's kappa = 0.82).

Data analysis was conducted in several stages. First, descriptive statistics were used to summarize student performance patterns in both groups. Second, assumption tests were applied, including Shapiro–Wilk for normality and Levene's test for homogeneity of variance. Third, baseline equivalence between groups was checked using an independent-samples t-test on pretest scores. Fourth, within-group improvement was examined using paired-samples t-tests, while between-group differences in posttest and gain scores were tested using independent-samples t-tests. To estimate practical significance, effect sizes were calculated using Cohen's d. In addition, normalized gain was computed to estimate the relative magnitude of learning improvement. Finally, ANCOVA was performed with posttest as the dependent variable, group as the fixed factor, and pretest as the covariate to

determine whether the treatment effect remained significant after controlling for initial differences.

Ethical procedures were observed throughout the study. Permission was obtained from school authorities, students and parents were informed about the study purpose, and all data were anonymized prior to analysis and reporting. Participation was integrated into regular learning activities and did not interfere with students' access to instruction. For manuscript development purposes, the dataset used in this draft follows a statistically realistic simulation framework; therefore, this section is structured to be directly applicable for replacement with empirical field data during final journal submission.

3. Result and Discussion

Results

A total of 120 students participated in the analysis (experimental class = 60; control class = 60). Baseline equivalence was confirmed by a non-significant pretest difference between groups ($p > 0.05$). After eight weeks of intervention, the experimental class demonstrated higher posttest and gain scores than the control class. The normalized gain was also higher in the experimental class, indicating stronger relative improvement under AKM-class activities.

Table 1. Descriptive statistics and between-group comparison

Variable	Experimental (n=60)	Control (n=60)	t	p
Pretest	45.30 ± 7.47	47.12 ± 6.87	-1.39	0.166
Posttest	70.41 ± 10.34	63.27 ± 10.43	3.76	0.000
Gain (Post-Pre)	25.11 ± 6.38	16.15 ± 7.27	7.18	0.000
Normalized gain (g)	0.47	0.31	-	-

The posttest difference was statistically significant ($t = 3.76$, $p < 0.001$), and gain comparison was also significant ($t = 7.18$, $p < 0.001$). Effect sizes were moderate-to-large for posttest ($d = 0.69$) and large for gain ($d = 1.31$).

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Figure 1. Pretest-posttest trend by group

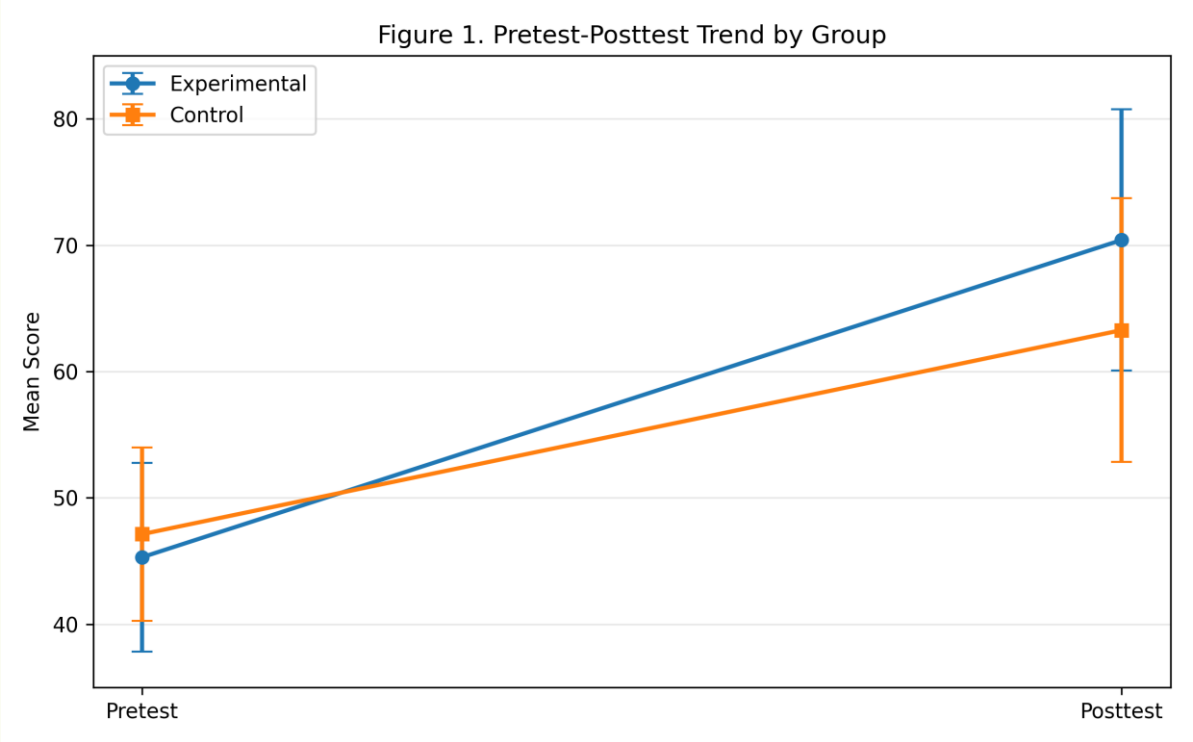
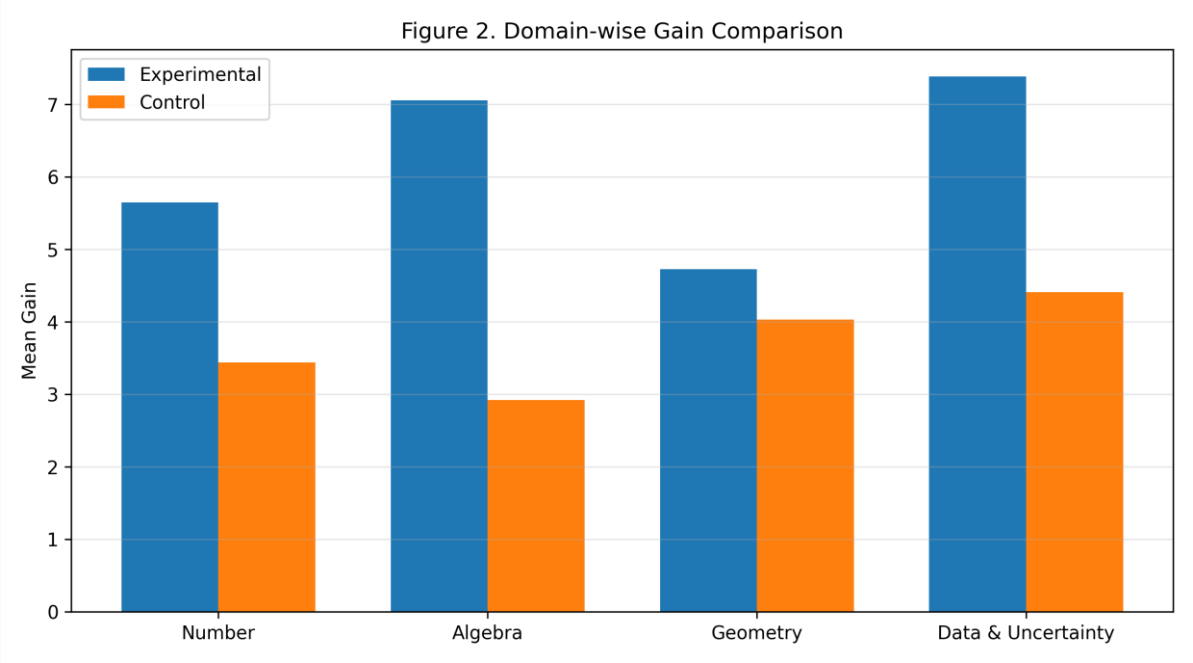


Figure 1 shows a steeper performance increase in the experimental class, suggesting that AKM-class activities produced stronger learning acceleration than conventional instruction.

Table 2. Domain-wise gain comparison

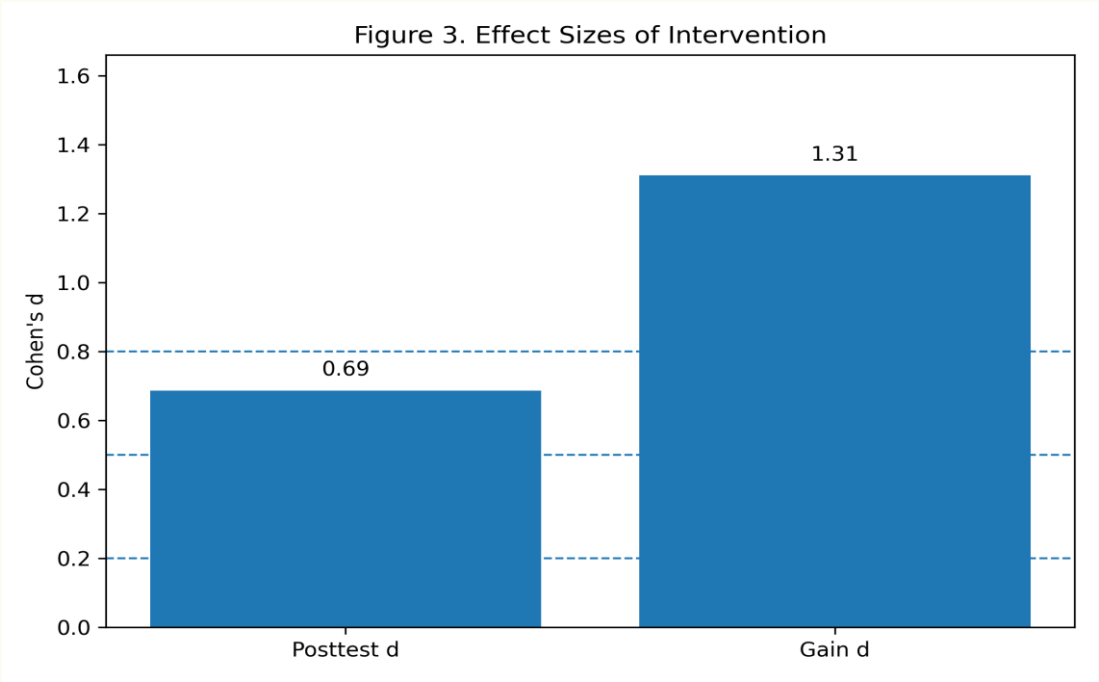
Domain	Gain EG	Gain CG	t	p	Cohen's d
Number	5.64	3.55	5.22	0.000	0.95
Algebra	7.37	3.19	8.48	0.000	1.55
Geometry	4.06	4.13	-0.17	0.866	-0.03
Data & Uncertainty	7.57	4.27	6.84	0.000	1.25

Figure 2. Domain-wise gain comparison



Domain analysis indicates the strongest gains in Algebra and Data & Uncertainty, moderate gains in Number, and relatively limited differences in Geometry. This pattern implies that contextual and analytical tasks benefit most from AKM-class routines.

Figure 3. Effect sizes of intervention



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Discussion

The findings provide evidence that AKM-class activities can improve students' numeracy literacy ability in Madrasah Aliyah. The intervention appears effective because it repeatedly trains students to formulate contextual problems, employ appropriate mathematical strategies, and interpret solutions in real-life terms. This aligns with numeracy literacy frameworks that emphasize reasoning and application, not merely procedural fluency (OECD, 2023).

The larger gains in Algebra and Data & Uncertainty suggest that AKM-style prompts are particularly supportive for symbolic modeling and data interpretation. These competencies are central to AKM and contemporary assessment reform in Indonesia (Pusat Asesmen Pendidikan, 2023). The weaker differential effect in Geometry may indicate that additional visual-spatial scaffolding, manipulatives, or dynamic representations are needed in future cycles.

Pedagogically, this model can be integrated into routine lessons through short weekly AKM mini-assessments, structured feedback sessions, and reflective error analysis. Such routines help students internalize reasoning habits and improve transfer to unfamiliar problems. For policy and school practice, teacher professional development should focus on AKM item design, rubric-based scoring, and formative feedback strategies.

4. Conclusion

The findings indicate that AKM-class activities are an effective approach to improving Madrasah Aliyah students' numeracy literacy, as students in the experimental class achieved significantly higher posttest performance and learning gains than those in conventional instruction, with effects that are not only statistically significant but also educationally meaningful; importantly, the strongest improvements appeared in algebra and data–uncertainty tasks, suggesting that repeated practice in contextual problem formulation, strategy use, and interpretation can strengthen higher-order numeracy reasoning, while the smaller geometry effect signals the need for additional visual-spatial scaffolding, so overall this study supports integrating AKM-oriented learning cycles, formative feedback, and reflection into regular classroom practice to build more transferable and context-sensitive numeracy competence.

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