Baamboozle-Assisted Game-Based Learning to Enhance Senior High School Students' Mathematical Reasoning and Learning Focus Viewed from Al-Qur'an Memorization Achievement

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Abstract

This study is motivated by the challenges of digital technology development that trigger distraction and diminish students' mathematical reasoning abilities and learning focus. This study aims to analyze whether the utilization of a Baamboozle-assisted Game-Based Learning model improves senior high school students' mathematical reasoning and learning focus compared to conventional learning, and to review its interaction effects based on the stratification of Al-Qur'an memorization achievements. The research method is a mixed-methods explanatory sequential design conducted at SMAIT As-Syifa Boarding School. The quantitative phase utilized a quasi-experimental Non-Equivalent Control Group Design on two sample grade XII classes (experimental and control) with test and questionnaire data collection techniques, analyzed using t-tests and Two-Way ANOVA via SPSS. The qualitative phase used online in-depth interview data collection via WhatsApp with five Extreme Case Analysis informants, analyzed using the interactive model of Miles, Huberman, and Saldaña to explain the quantitative results. Quantitative results showed a marginal significance of the learning method on mathematical reasoning scores, indicating that the GBL Baamboozle model has a better impact on enhancing reasoning and attention stability compared to the conventional method. The Two-Way ANOVA proved no significant combinational interaction effect on either reasoning or learning focus, demonstrating that its effectiveness is

universal and inclusive across all memorization tiers. Qualitatively, this model is proven to trigger peer scaffolding, visual-tactical strategies, and peer tutoring. Meanwhile, Al-Qur'an memorization acts as an indirect cognitive catalyst through dawn cognitive warm-ups and the formation of auditory selective attention as a cognitive buffer against classroom distractions.

Keywords: *Game-Based Learning, Baamboozle, Mathematical Reasoning, Learning Focus, Al-Qur'an Memorization*

INTRODUCTION

Mathematics is a foundational science that underlies the development of modern technology and fosters logical, critical, and systematic thinking skills. However, mathematics is traditionally perceived as a difficult, complex, and tedious subject by most students, which often triggers cognitive boredom and disengagement during the learning process (Maulyda & Mudrikah, 2023; Yaniawati et al., 2023). This problematic paradigm leads to a severe decline in students' mathematical higher-order thinking skills, particularly in non-routine problem-solving and algebraic reasoning. Recent assessments show that Indonesian students' problem-solving abilities remain predominantly in the low category, especially when facing tasks within the algebra and "Change and Relationship" domains (Putra et al., 2025). This deficiency occurs because students are structurally prone to making substantial errors in horizontal mathematization, failing to translate complex real-world narratives into accurate mathematical models (Putra et al., 2025). Furthermore, the rapid surge of digital distractions, unregulated device usage, and mental fatigue acutely disrupts students' sustained attention and learning focus in the classroom.

To address these cognitive and behavioral barriers, the integration of instructional technology has become an absolute necessity to accelerate students' conceptual understanding (Yaniawati et al., 2023). Technological developments open up significant opportunities to transform abstract mathematical objects into semi-concrete, interactive, and dynamic representations. Nevertheless, full digital dependency or unguided self-learning (*full e-learning*) cannot serve as a single solution because the instructional role of teachers as facilitators cannot be replaced entirely by information technology (Yaniawati, 2012). Therefore, a hybrid or *blended learning* model that combines the strengths of conventional teacher

guidance with the flexibility of digital tools is highly required to optimize students' mathematical power (Yaniawati, 2012; Yaniawati et al., 2023). By anchoring digital learning materials to realistic or problem-based approaches, students are given a rich pedagogical environment to reconstruct and internalize mathematical rules meaningfully (Maulyda & Mudrikah, 2023; Mudrikah et al., 2020).

In the context of Islamic boarding schools (*pesantren*), students face a unique dual-curriculum environment that demands high cognitive resilience. While the intensive routine of Al-Qur'an memorization (*tahfiz*) trains working memory and concentration baseline, the dense daily schedule often leaves students vulnerable to *ego depletion* and physical exhaustion during late-hour academic classes. Interestingly, previous studies have verified that boarding school students inherently possess a robust capacity for conceptual understanding and a positive mathematical disposition when their learning environment is student-centered, active, and supported by adaptive learning tools (Mudrikah et al., 2020). This brings a critical opportunity to introduce Game-Based Learning (GBL) platforms, such as Baamboozle, into the *blended learning* environment. Baamboozle features short-round team modes, instant feedback, and visual reward structures that act as a *dopamine trigger* to interrupt cognitive boredom, foster social-group collaboration, and maintain continuous attention control.

Although research on gamification in mathematics has expanded, several major limitations persist in the existing literature. First, prior studies on platform responses like Baamboozle remain heavily confined to primary education or fundamental arithmetic operations, ignoring higher-order mathematical reasoning at the senior high school level. Second, previous inquiries on digital tools typically isolate cognitive achievements from behavioral atention variables, failing to measure how interactive elements directly mitigate classroom noise and internal mind-wandering. Third, existing literature regarding the cognitive effects of Al-Qur'an memorization is dominantly descriptive or correlational within conventional instruction, leaving a scientific gap on how these religious-spiritual habits act as a cognitive moderator when interacting with digital gamification. To investigate these multi-dimensional variables accurately, a mixed-methods explanatory sequential

design is highly advantageous to dissect both macro-statistical trends and micro-behavioral phenomena in a real-world setting (Yaniawati et al., 2019).

The scientific merit and novelty of this study lie in its comprehensive synthesis of digital pedagogy (GBL Baamboozle), cognitive development (mathematical reasoning), psychological behavior (learning focus), and spiritual habituation (Al-Qur'an memorization) within a unified *blended learning* experimental design at a boarding school. Hence, the objective of this study is to analyze whether the utilization of a Baamboozle-assisted GBL model improves senior high school students' mathematical reasoning and learning focus compared to conventional learning, and to evaluate the interaction effects between the instructional methods and the stratification of Al-Qur'an memorization levels.

METHOD

Research Design

This study employed a mixed-methods approach with an explanatory sequential design (*The Explanatory Sequential Design*), where quantitative data collection and analysis served as the primary phase, followed by a secondary qualitative phase to explain and deepen the macro-statistical findings (Yaniawati et al., 2019). In the first phase, a quasi-experimental approach using the *Non-Equivalent Control Group Design* was applied to evaluate the causal effects of the instructional treatments. The structural framework of the quantitative design is illustrated in Table 1.

Table 1 quantitative design

Group	Pre-test	Treatment	Post-test
Experimental Class (n=24)	O_1	X	O_2
Control Class (n=23)	O_1	-	O_2

Participants and Sampling

The research population comprised all senior high school students at SMAIT As-Syifa Boarding School Subang, West Java, Indonesia. The sample was selected using a cluster random sampling technique, which resulted in two intact grade XII

classes: class XII Saintek 3 as the experimental group ($n = 24$) and class XII Saintek 2 as the control group ($n = 23$).

In the second phase, a purposive sampling technique based on *Extreme Case Analysis* was utilized to select five key informants for the qualitative inquiry. The qualitative sample consisted of three students from the experimental class (representing optimal post-test scores across low, medium, and high Al-Qur'an memorization levels) and two students from the control class (representing a case of cognitive stagnation and a quantitative anomaly case).

Operational Variables and Instruments

The independent variable in this study was the instructional model (Baamboozle-assisted GBL versus conventional learning). The dependent variables consisted of mathematical reasoning (Y_1) and learning focus (Y_2), while the moderator variable was the students' Al-Qur'an memorization achievement (Z). The moderator variable was stratified into three official school categories: High (≥ 10 juz), Medium ($5 - 9$ juz), and Low (< 5 juz).

Data collection was executed through the following instruments:

1. **Mathematical Reasoning Test:** A written essay test consisting of five non-routine contextual problems on Probability (*Peluang*). The test instrument was validated through expert judgment and pilot-tested (N=26) using the Pearson Product-Moment correlation, yielding valid coefficients ($p < 0.05$) for all items with a high Cronbach's Alpha reliability (\alpha = 0.738).
2. **Learning Focus Questionnaire:** A psychometric instrument utilizing a 5-point Likert scale to measure four dimensions of attention control based on Goleman’s framework: selective attention, sustained attention, executive control, and inner focus.
3. **Interview Guidelines:** A semi-structured digital interview protocol designed to track students' internal trace of reasoning, social dynamics under time pressure, and cross-domain cognitive transfer from daily *tahfiz* routines.

Data Analysis Procedures

Quantitative data from pre-test, post-test, and Normalized Gain (N-Gain) scores were processed using SPSS software. Prior to the hypothesis testing, parametric prerequisite assumptions were analyzed. The normality of data distribution was verified using the Shapiro-Wilk test (due to the group sample size < 50), and the variance homogeneity was examined via Levene's Test. An Independent Samples t-Test was conducted on the pre-test scores to establish baseline equality between the two groups. Subsequently, a Two-Way ANOVA was executed at a significance level of $\alpha = 0.05$ to examine the main effects of the learning models, the main effects of the memorization levels, and the multiplicative interaction effects (Method \times Memorization) on mathematical reasoning and learning focus.

Qualitative textual data from the WhatsApp instant messaging interviews (text logs and transcribed voice notes) were processed following the interactive model of Miles, Huberman, and Saldaña. This process involved three simultaneous stages: data reduction (cleaning non-formal language and coding text based on reasoning and focus indicators), data display (organizing thick descriptive narratives based on the five extreme case informers), and conclusion drawing or verification. Finally, a connecting phase was applied to synthesize the micro-behavioral qualitative narratives to explain the macro-statistical output of the Two-Way ANOVA.

RESULTS AND DISCUSSION

Quantitative Results

Prior to evaluating the main effects and interaction effects of the variables, data from the mathematical reasoning test and learning focus questionnaire were subjected to prerequisite statistical assumptions tests. Since the group sample sizes were under 50 ($n < 50$), the normality of the Normalized Gain (N-Gain) data distribution was calculated using the Shapiro-Wilk test (Maulyda & Mudrikah, 2023). The statistical summary of the normality test is presented in Table 2.

Table 2 The statistical summary of the normality test

Variable	Group	Statistic	df	Sig. (p)
N-Gain Reasoning	Experimental	0.963	24	0.512
	Control	0.930	23	0.108

As displayed in Table 2, the N-Gain data for both the experimental class ($p = 0.512 > 0.05$) and the control class ($p = 0.108 > 0.05$) were normally distributed. Subsequently, the variance homogeneity of the error distribution across the combinations of learning methods and memorization levels was analyzed using Levene's Test, as summarized in Table 3.

Table 3 Levene's Test

Dependent Variable	F	df1	df2	Sig. (p)
N-Gain Reasoning	1.623	5	41	0.176

The Levene's Test result ($F = 1.623$; $p = 0.176 > 0.05$) confirmed that the error variances across the groups were equal or homogeneous. To guarantee a valid assessment of the instructional treatment, the equality of students' baseline mathematical reasoning was analyzed using an Independent Samples t-Test on the pre-test scores, revealing no significant initial difference between the experimental and control groups ($t = 1.332$; $p = 0.190 > 0.05$). The descriptive profile of the students' N-Gain reasoning across all levels of Al-Qur'an memorization is fully compiled in Table 4.

Table 4 descriptive profile of the students' N-Gain reasoning

Memorization Level	Instructional Group	Mean	Std. Deviation	N
Low (<5 Juz)	Experimental (GBL Baamboozle)	0.7572	0.03599	2
	Control (Conventional)	0.5087	0.38285	4
Medium (5-9 Juz)	Experimental (GBL Baamboozle)	0.5936	0.22103	17
	Control (Conventional)	0.4630	0.24014	14
High (≥ 10 Juz)	Experimental (GBL Baamboozle)	0.7564	0.16075	5
	Control (Conventional)	0.6498	0.30447	5
Total Profile	Experimental (GBL Baamboozle)	0.6411	0.21039	24

	Control (Conventional)	0.5115	0.27707	23

The central hypothesis testing was executed via General Linear Model (GLM) Two-Way ANOVA on the post-test scores to simultaneously isolate the main effects and the interaction effects, as structured in Table 5.

Table 5 General Linear Model (GLM) Two-Way ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p)	Partial Eta Squared
Corrected Model	3264.380	5	652.876	2.220	0.071	0.213
Intercept	164572.966	1	164572.966	559.610	0.000	0.932
Memorization (Z)	1414.638	2	707.319	2.405	0.103	0.105
Method (X)	970.214	1	970.214	3.299	0.077	0.074
Method × Memorization	345.220	2	172.610	0.587	0.561	0.028
Error	12057.492	41	294.085			
Corrected Total	15321.872	46				

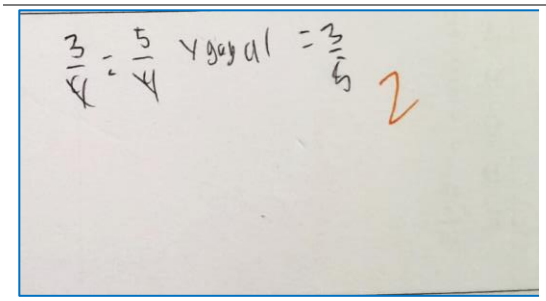
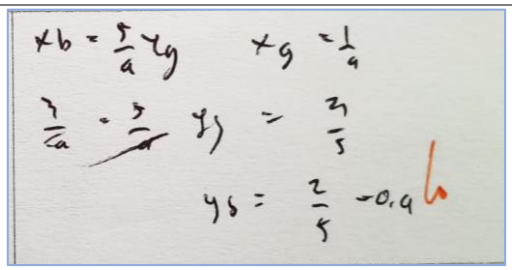
As shown in Table 5, the main factor of the learning method yielded $p = 0.077$, which represents a marginal significance ($p < 0.10$). This indicates a robust tendency that the GBL Baamboozle model provides a better impact on mathematical reasoning compared to conventional approaches. In contrast, the main effect of memorization levels ($p = 0.103 > 0.05$) and the multiplicative interaction effects ($p = 0.561 > 0.05$) were statistically non-significant. This implies that the Baamboozle-assisted GBL model works universally, independently, and inclusively for all students across different levels of Al-Qur'an memorization.

Discussion: Qualitative Insights and Connecting Phase

1. Optimization of Mathematical Reasoning Indicators

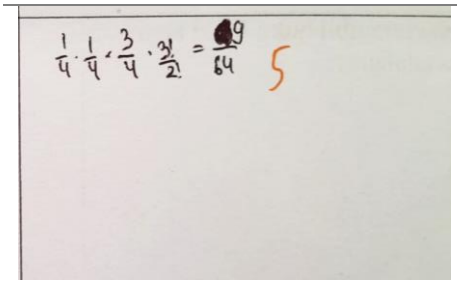
The statistical independence of the interaction ($p = 0.561$) signifies that the gamification design works adaptively across diverse cognitive-spiritual settings. To look closely into this phenomenon, qualitative tracking of extreme cases was explored based on the four indicators of mathematical reasoning.

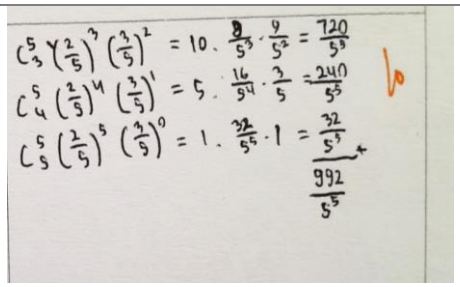
In the experimental class, Informant E-1 (Low Memorization/High Post-test) successfully bypassed short-term memory constraints through social interactions. Although prone to immediate procedural algorithms without formal problem transcription, the team mode in Baamboozle catalyzed intensive *peer scaffolding*. Informant E-1 extracted more efficient problem-solving paths during team debates and internalized these strategies for the post-test. This visual-tactical acceleration is illustrated through the post-test answer sheet configurations below:

Pre-Test	**Post-Test**
	

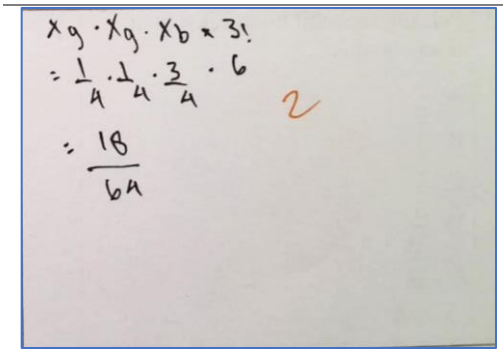
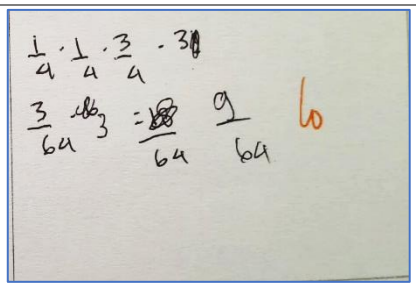
Furthermore, Informant E-2 (Medium Memorization/High Post-test) utilized the visual features of Baamboozle as an absolute *attentional anchor* to simplify abstract probability logic. Interestingly, the element of time pressure acted as a positive adrenaline catalyst rather than a cognitive disrupter, pushing Informant E-2 to develop abstract representation mechanics (*in-head processing*) before formal writing. This process is visualized in Figure 3:

Pre-Test	**Post-Test**



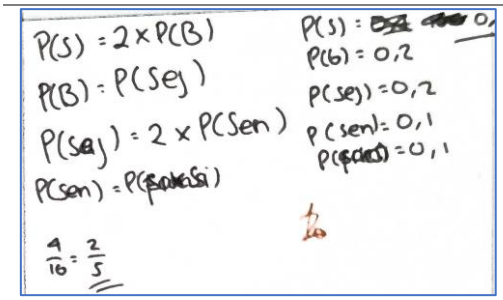


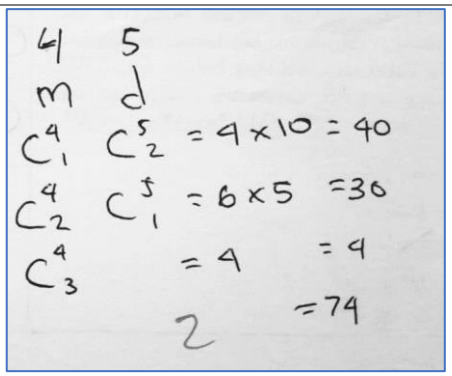
For Informant E-3 (High Memorization/High Post-test), the gamified setting provided a robust space for *peer tutoring* and critical debate. Informant E-3, possessing superior information processing speed, used the explanation phases to crystallize his own conceptual structures, leading to high rigor and accuracy in mathematical proof. This advanced structural trace is documented in Figure 4:

Pre-Test	**Post-Test**
	

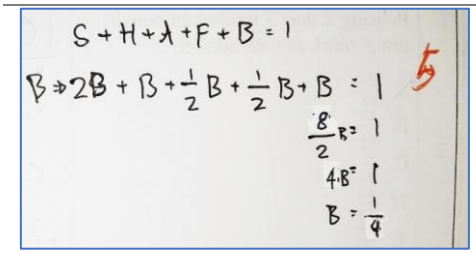
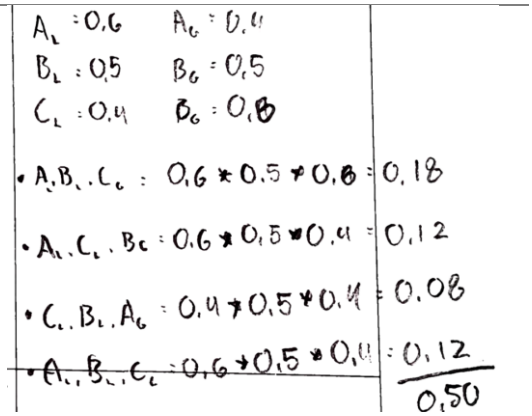
Conversely, the control class narratives uncovered why conventional direct instruction trapped students in an acute state of *algorithmic dependence*. Informant K-1 (Low Memorization/Low Post-test) experienced severe *cognitive rigidity*, only capable of solving problems identical to the teacher's whiteboard examples. Any contextual reverse or variable modification triggered an instant mental block, leaving his reasoning stagnant under *ego depletion* caused by classroom noise and physical fatigue. The rigid structural trace of Informant K-1 is shown in Figure 5:

Pre-Test	**Post-Test**





An anomaly occurred with Informant K-2 (Low Memorization/High Post-test), who excelled in the control group despite the static lecture format. His growth was purely driven by future-oriented motivation (university entrance selection) and the presence of a competitive peer seated next to him, turning his neighbor into a *peer verification instrument* to validate answers. This systematic procedural trace is confirmed in Figure 6:

Pre-Test	**Post-Test**
	

This combined pattern demonstrates that while students' core procedural understanding of equation formatting remains intact reflected by the 0% error rate in equation syntax their actual breakdown occurs at the stage of mathematical modeling (Putra et al., 2025). Most students fail to execute horizontal mathematization, which is the exact phase that the Baamboozle-driven team discussions managed to scaffold effectively through visual aids and interactive peers (Maulyda & Mudrikah, 2023; Yaniawati et al., 2023).

2. Dynamics of Attention Control and the Role of Al-Qur'an Memorization

The non-significant interaction for learning focus ($p = 0.103$) uncovers a profound cognitive phenomenon: the daily *tahfiz* program serves as an indirect cognitive catalyst (*general cognitive sharpening*) that establishes a solid baseline for focus control.

The intensive routine of *ziyadah* and *muraja'ah* at dawn operates as a critical *cognitive warm-up* that exercises neural pathways under high memory retention demands. This morning habituation optimizes the brain's executive functions, providing students with *cognitive readiness* to digest abstract mathematics later in the day. For students with high memorization benchmarks (like Informants E-3 and K-1), this spiritual discipline trains the brain to isolate attention from external disruptions. This mental mechanism generates an *auditory selective attention* capacity, operating as a robust *cognitive buffer* that allows students to mentally block classroom noise and maintain concentration even in less conducive environments.

However, the field data also presents a warning regarding *cognitive overload* (Brousseau, 2011; Putra et al., 2025). When the heavy target of memorization is forced under a purely monotonous and exhausting lecture format, the mental buffer collapses into severe *ego depletion*. This explains the behavioral collapse of Informant K-1, who suffered from heavy fatigue and diminished self-efficacy.

Therefore, a hybrid or *blended learning* structure is essential. By embedding a highly gamified platform like Baamboozle, the digital reward loops trigger dopamine releases that immediately cut through the cognitive fatigue of boarding school routines (Yaniawati et al., 2023). Crucially, the gamification must remain *blended* and balanced with direct whiteboard conceptual reviews by the teacher, ensuring that students with deep-processing cognitive styles are not marginalized by the rapid, competitive pace of the digital game (Yaniawati, 2012).

CONCLUSION

Based on the mixed-methods sequential explanatory analysis, several core scientific conclusions are drawn to answer the research objectives. First, the implementation of the Baamboozle-assisted Game-Based Learning (GBL) model provides a better

impact on enhancing senior high school students' mathematical reasoning compared to conventional direct instruction, as evidenced by a marginal statistical significance ($p = 0.077$). The team-driven mechanics of the game effectively dissolve the rigid bounds of algorithmic dependence and cognitive rigidity that typically isolate students in conventional direct-lecture environments. Second, the utilization of this interactive digital platform successfully stabilizes and elevates students' learning focus by operating as an instructional dopamine trigger that cuts through cognitive boredom and dampens classroom noise disruptions.

Third, the statistical results prove that there is no significant combinational interaction effect between the learning methods and Al-Qur'an memorization levels on mathematical reasoning ($p = 0.561$) or learning focus ($p = 0.103$). Metodologically, this highlights the universal, independent, and inclusive nature of the GBL Baamboozle model, which means the platform works effectively across all student clusters regardless of their memorization workloads. Qualitatively, the model facilitates peer scaffolding for low-memorization students, tactical-visual representations for medium-memorization students, and deep metacognitive peer tutoring for high-memorization students. Lastly, Al-Qur'an memorization harian is explicitly confirmed to act as an indirect cognitive catalyst (*general cognitive sharpening*). The dawn *ziyadah* and *muraja'ah* routines serve as a mental warm-up that expands working memory capacity and nurtures auditory selective attention, which serves as a protective cognitive buffer to suppress classroom environment disruptions.

The primary limitations of this study include the restriction of device access due to strict boarding school regulations and sample fluctuation near the academic year-end. For future extensions, investigators are encouraged to develop broader digital game architectures integrated with cross-platform compatibility and incorporate eye-tracking observation methods to obtain a more precise real-time measurement of attention control variables.

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