

Improvement of students' mathematical problem-solving ability through kuga story-based learning with wordwall

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Abstract

Mathematics learning, particularly solving word problems, remains challenging for students due to conceptual gaps and difficulties in identifying relevant information in problem situations. This study examines students' mathematical problem-solving outcomes after using KUGA story-based geometry quizzes integrated with Wordwall as an interactive, game-based learning medium. The study employed a quantitative approach with a one-group pretest-posttest design. The participants were 21 seventh-grade students from MTs Hidayatul Islam. Data were collected through pretests, posttests, and documentation. KUGA was used to provide story-based geometry quiz content, while Wordwall served as an interactive digital platform for presenting and delivering the quizzes in a game-based format. Data were analyzed through normality testing, followed by the Wilcoxon Signed-Rank test and N-Gain analysis to examine changes in students' mathematical problem-solving outcomes. The results showed an increase in the mean score from 67.14 on the pretest to 82.38 on the posttest. The Wilcoxon Signed-Rank test indicated a statistically significant difference between the pretest and posttest scores ($p < 0.001$). The N-Gain score was 0.4536, categorized as moderate. These results indicate an improvement in students' mathematical problem-solving outcomes following the implementation of KUGA story-based geometry quizzes integrated with Wordwall. However, because the study used a one-group pretest-posttest design without a control group, the observed improvement cannot be attributed solely to the intervention. Therefore, the findings should be interpreted as evidence of improvement following the implementation rather than definitive evidence of a causal effect.

Keywords: KUGA, Mathematics Learning, Problem-Solving Ability, Word Problems, Wordwall,

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INTRODUCTION

Mathematics learning plays an important role in developing students' logical, analytical, critical, and creative thinking. Beyond understanding mathematical concepts, students need to apply these concepts to solve contextual problems. Mathematical problem-solving ability is, therefore, an essential competency because it involves understanding problems, determining appropriate strategies, carrying out procedures, and evaluating solutions. The National Council of Teachers of Mathematics (NCTM, 2000) identifies problem solving as a central process in mathematics learning, while recent

research positions it as a mathematical practice involving the formulation, exploration, representation, and evaluation of problems (Santos-Trigo, 2024; Rott et al., 2021). In mathematical word problems, students must identify relevant information, connect it with appropriate mathematical concepts, and interpret the resulting solution. These processes correspond to Polya's framework: understanding the problem, devising a plan, carrying out the plan, and looking back. Previous studies have used these stages to analyze students' difficulties in solving mathematical word problems (Alfiandari, 2022; Nurizlan et al., 2022).

Despite its importance, students continue to experience difficulties in solving contextual mathematical problems, particularly in identifying relevant information, selecting appropriate strategies, applying procedures, and drawing conclusions (Lutvaidah et al., 2021; Nurizlan et al., 2022; Purba & Warmi, 2022). Such difficulties are also associated with students' ability to make sense of problem situations, as some students tend to apply familiar procedures without sufficiently interpreting the context (Prediger & Krägeloh, 2021). Difficulties may further arise from limited conceptual understanding and the ability to connect mathematical knowledge with problem situations (Ayu et al., 2021). These challenges can be more complex in geometry because students must understand figures, properties, measurements, and relationships among concepts. Susanto and Mahmudi (2021) found differences in junior high school students' levels of geometric thinking, highlighting the need for learning experiences that strengthen conceptual understanding and mathematical reasoning. Similar concerns regarding mathematical problem-solving performance and its associated factors have also been reported in recent AKSIOMA research (Wahyuni, 2024).

The initial condition at MTs Hidayatul Islam was identified through a pretest conducted on April 23, 2026, involving 21 seventh-grade students. The test consisted of contextual problems involving triangles and quadrilaterals. The mean score was 67.14, with scores ranging from 20 to 90, and several students obtained relatively low scores of 20, 40, 45, and 50. These results indicate that students' initial problem-solving outcomes were not yet optimal and provide an empirical basis for implementing more interactive learning activities. In this study, mathematical problem-solving ability is operationally measured through four indicators adapted from Polya's stages: (1) understanding and

identifying relevant information, (2) devising an appropriate solution strategy, (3) carrying out the strategy accurately, and (4) evaluating or interpreting the solution.

The findings suggest the need for learning activities that actively engage students with contextual mathematical problems. Game-based learning offers a promising approach because it integrates learning objectives with interactive activities that encourage participation and provide opportunities for practice and feedback (Radityastuti et al., 2023; Hussein et al., 2022). Research has shown that game-based mathematics environments can support mathematical knowledge when activities are aligned with learning objectives (Brezovszky et al., 2019; Moyer-Packenham et al., 2019). Game-oriented learning has also demonstrated potential to support problem-solving, including through the Teams Games Tournament model (Anastasya et al., 2021), educational tangram games integrated with problem-based learning (Andika et al., 2025), and mathematics-based educational games using realistic mathematics approaches (Apriyanti et al., 2024).

Wordwall is a digital platform that facilitates interactive, game-based learning through various activity formats. Previous studies have developed Wordwall-based educational games and mathematics learning media (Aeni et al., 2022; Wildan et al., 2023), and have reported its potential to improve mathematical reasoning and learning outcomes (Richardo & Kholifah, 2023; Zulkarnain & Efendi, 2024). However, these studies have generally focused on Wordwall as a learning or assessment medium rather than specifically supporting contextual geometry word problems through Polya-based problem-solving indicators. Recent AKSIOMA studies have similarly explored digital and interactive media for mathematical problem solving, but have used different media, learning models, or mathematical topics (Adiastuty et al., 2025; Pratama & Sutriyani, 2025).

Based on the literature reviewed, the integration of a purpose-designed story-based geometry quiz, Polya-based problem-solving indicators, and Wordwall as an interactive delivery platform remains limited. Therefore, this study introduces KUGA (Kuis Geometri Angkasa), a story-based geometry learning activity focusing on triangles and quadrilaterals. KUGA presents contextual mathematical problems through narratives and requires students to engage in the problem-solving process rather than merely recall formulas. The activities are delivered through Wordwall in an interactive game-based

format. In this integration, KUGA serves as the mathematical content and problem-solving activity, while Wordwall functions as the digital platform for its presentation and delivery.

The novelty of this study lies in integrating purpose-designed story-based geometry problems with Wordwall to support the four stages of mathematical problem solving: identifying relevant information, developing solution strategies, carrying out procedures, and evaluating solutions. This design provides an interactive alternative to engage students with contextual geometry problems while generating empirical evidence of changes in their mathematical problem-solving outcomes.

Accordingly, this study aims to examine the improvement in seventh-grade students' mathematical problem-solving outcomes on triangle and quadrilateral topics following the implementation of KUGA story-based geometry quizzes integrated with Wordwall. Since the study uses a one-group pretest-posttest design without a control group, it examines changes in students' outcomes following the implementation rather than establishing a definitive causal effect. The research question is: "To what extent do seventh-grade students' mathematical problem-solving outcomes improve after learning through KUGA story-based geometry quizzes integrated with Wordwall on triangle and quadrilateral topics?" The hypothesis is that there is a statistically significant difference between students' mathematical problem-solving outcomes before and after the implementation of KUGA story-based geometry quizzes integrated with Wordwall.

METHODS

This study employed a quantitative approach with a pre-experimental one-group pretest-posttest design, represented as O_1-X-O_2 . O_1 represented the pretest, X represented the implementation of KUGA (Kuis Geometri Angkasa), a story-based geometry quiz integrated with Wordwall, and O_2 represented the posttest. The study was conducted at MTs Hidayatul Islam during the 2025–2026 academic year and involved 21 seventh-grade students selected through purposive sampling. The study focused on triangle and quadrilateral materials. The pretest was administered on April 23, 2026, followed by four intervention meetings from April 29 to May 9, 2026, each lasting 45 minutes. During the intervention, students solved contextual KUGA problems through Wordwall in an interactive game-based format. The posttest was administered after the intervention to examine changes in students' mathematical problem-solving outcomes. As there was no

control group, the design could not establish a definitive causal relationship between the intervention and the observed changes.

Data were collected through a mathematical problem-solving test and documentation. The test consisted of five contextual essay questions on triangles and quadrilaterals, with a maximum score of 100. The items were developed based on four indicators adapted from Polya's stages: (1) understanding the problem by identifying relevant information and what is asked, (2) devising an appropriate strategy, (3) carrying out the strategy accurately, and (4) evaluating or interpreting the solution. Each item was scored using a rubric based on these indicators. The instrument was validated by a lecturer for content and indicator suitability prior to administration. A reliability test was not conducted. Documentation was used as supporting data to record research implementation and student participation.

Data were analyzed using descriptive and inferential statistics. Descriptive analysis included the mean, median, standard deviation, minimum, and maximum scores. A normality test was conducted, and because the data were not normally distributed, the Wilcoxon Signed-Rank Test was used to examine differences between pretest and posttest scores at a 0.05 significance level. Effect size was calculated using $r = Z/\sqrt{N}$, with 0.10, 0.30, and ≥ 0.50 interpreted as small, moderate, and large effects, respectively. N-Gain was also calculated using $g = (Posttest - Pretest)/(100 - Pretest)$ and interpreted as low ($g < 0.30$), moderate ($0.30 \leq g < 0.70$), or high ($g \geq 0.70$). The N-Gain category was applied consistently throughout the Results, Discussion, and Conclusion. Given the absence of a control group, the statistical findings were interpreted as evidence of changes in students' mathematical problem-solving outcomes following the intervention, rather than definitive evidence of a causal effect of KUGA integrated with Wordwall.

RESULTS AND DISCUSSION

The results indicate an improvement in students' mathematical problem-solving outcomes following the implementation of KUGA story-based geometry quizzes integrated with Wordwall. The descriptive statistics are presented in Table 1.

Table 1. Descriptive Statistics of Students' Mathematical Problem-Solving Scores

Statistic	Pretest	Posttest
N	21	21
Mean	67.14	80.71
Median	70.00	80.00
Standard Deviation	17.51	9.52
Minimum	20	60
Maximum	90	95

The mean score increased by 13.57 points, from 67.14 to 80.71, while the median increased from 70.00 to 80.00. The maximum score increased from 90 to 95, and the minimum score increased from 20 to 60. The standard deviation decreased from 17.51 to 9.52, indicating that the posttest scores were more concentrated around the mean. These results suggest an improvement in students' mathematical problem-solving outcomes.

A Shapiro-Wilk test was conducted to determine the distribution of the pretest and posttest scores. The results are presented in Table 2.

Table 2. Results of the Shapiro-Wilk Normality Test

Results of soal cerita pemecahan	Shapiro-Wilk		
	Statistic	df	Sig.
pretest	,904	21	,041
posttest	,936	21	,182

The pretest data were not normally distributed ($p = 0.041 < 0.05$), whereas the posttest data did not significantly deviate from normality ($p = 0.182$). Because the scores were paired observations from the same 21 students and the pretest data did not meet the assumption of normality, the Wilcoxon Signed-Rank Test was used.

Table 3. Results of the Wilcoxon Signed-Rank Test**Test Statistics^a**

	postes - pretes
Z	-3,373 ^b
Asymp. Sig. (2-tailed)	<,001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

The Wilcoxon Signed-Rank Test showed a statistically significant difference between the pretest and posttest scores ($Z = -3.373$, $p < 0.001$). Twenty students obtained higher posttest scores, while one student obtained a lower score, with no tied scores. The effect size was $r = |Z|/\sqrt{N} = 0.736$, indicating a large effect. However, because the study used a one-group pretest-posttest design without a control group, this result indicates a significant change but does not establish a definitive causal effect of the intervention.

N-Gain analysis was conducted to examine the magnitude of improvement. The results are presented in Table 4.

Table 4. N-Gain Analysis of Students' Mathematical Problem-Solving Scores

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain score	21	,20	,67	,4536	,11164
Ngain Persen	21	20,00	66,67	45,3638	11,16388
Valid N (listwise)	21				

The mean N-Gain score was 0.4536 (45.36%), indicating a moderate level of normalized improvement ($0.30 \leq g < 0.70$). Combined with the Wilcoxon result and large effect size, the findings indicate a statistically significant improvement with moderate normalized gain. The improvement may be related to KUGA's story-based structure, which presents contextual triangle- and quadrilateral-based problems that require students to identify relevant information, develop and apply strategies, and evaluate solutions. These activities align with Polya's four problem-solving stages (Alfiandari, 2022; Nurizlan et al., 2022) and support the view that mathematical problem solving involves interconnected processes that extend beyond formula application (Rott et al., 2021; Santos-Trigo, 2024).

KUGA also addresses difficulties identified during the preliminary observation, particularly in identifying known and asked information, selecting appropriate strategies, and formulating conclusions. By requiring students to interpret contextual situations before applying procedures, KUGA may encourage connections between problem

information and geometric concepts (Lutvaidah et al., 2021; Nurizlan et al., 2022; Purba & Warmi, 2022).

Wordwall functioned as the interactive platform for delivering KUGA, while KUGA provided the mathematical content and problem-solving activities. Therefore, the findings should be attributed to their combined implementation rather than Wordwall alone. This is consistent with research showing that digital game-based learning can support mathematics when interactive features are aligned with learning objectives (Hussein et al., 2022; Moyer-Packenham et al., 2019). The findings are also consistent with previous studies reporting the potential of game-based approaches for mathematical problem solving and conceptual understanding (Anastasya et al., 2021; Andika et al., 2025; Apriyanti et al., 2024).

The moderate N-Gain suggests meaningful but non-maximal improvement. Twenty students improved their scores, while one student's score decreased, possibly reflecting differences in initial understanding, familiarity with contextual problems, and strategy selection. The four-meeting intervention may also have limited opportunities for repeated practice.

Several limitations should be noted. The small sample of 21 students from one school limits generalisability, while the absence of a control group prevents definitive causal conclusions. One lecturer validated the test but did not reliability-test it, and students' motivation and engagement were not directly measured. Future studies should use larger samples, comparison groups, more rigorous designs, reliable instruments, and validated measures of affective outcomes where relevant.

CONCLUSION

This study examined improvements in seventh-grade students' mathematical problem-solving outcomes after implementing KUGA (Kuis Geometri Angkasa), story-based geometry quizzes integrated with Wordwall, on triangle and quadrilateral topics. The results showed improved pretest-to-posttest scores, supported by a statistically significant Wilcoxon Signed-Rank Test and a moderate N-Gain. These findings suggest that integrating KUGA and Wordwall has the potential to provide interactive opportunities for students to engage with contextual geometry problems and practice key problem-solving processes, including identifying relevant information, developing

strategies, applying procedures, and interpreting solutions. However, the findings indicate improvement following the intervention rather than definitive evidence of a causal effect. The study was limited by the small sample from one school, the one-group pretest-posttest design without a control group, and the absence of reliability testing for the instrument. Future research should involve larger and more diverse samples, comparison or control groups, more rigorous research designs, and reliable measurement instruments to provide stronger evidence of the potential contribution of KUGA integrated with Wordwall to students' mathematical problem-solving abilities.

DECLARATIONS

Author Contribution : MSA: Conceptualization, Data Collection, Data Processing, Formal Analysis, Methodology, Writing–Original Draft, and Editing; NK: Writing-Review & Editing, Validation, and Supervision; MHA: Validation, Supervision, and Writing–Review & Editing)

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