JURNAL PENDIDIKAN MATEMATIKA DAN IPA

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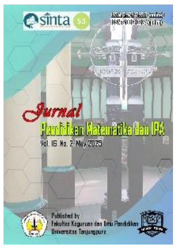

REALISTIC MATHEMATICS EDUCATION AND ETHNOMATHEMATICS WORKSHEETS: A COMPARATIVE EFFECTIVENESS STUDY

Muhamad Irfan Anshori[1]*, Syarifah Inayati[2], Alifatul Chasanah[3], Mohammad Rosyid Ridho[4], Risal Abu Jaya[5]

[1*,2,3,4,5] Universitas Negeri Yogyakarta, Jl. Colombo No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta

Email Corresponding: muhamadirfan.2025@student.uny.ac.id

DOI: https://doi.org/10.26418/jpmipa.v17i2.102269

Abstract

Low quantitative literacy and mathematical problem-solving skills among Indonesian students are the background for this study. This study aims to compare the effectiveness of using worksheets based on Realistic Mathematics Education (RME) and worksheets based on Ethnomathematics in improving the quantitative literacy and mathematical problem-solving skills of high school students in spatial geometry. This study used a quantitative experimental method with a posttest control group design involving two treatment groups. The research sample consisted of 100 high school students divided into two treatment groups, one group using RME-based worksheets and one group using ethnomathematics-based worksheets. The research instruments were quantitative literacy tests and mathematical problem-solving ability tests on spatial geometry material. The results showed that students who learned using RME-based worksheets obtained significantly higher quantitative literacy and mathematical problem-solving ability scores than students who learned using ethnomathematics-based worksheets. MANOVA analysis followed by univariate ANOVA confirmed significant differences in both variables. In conclusion, RME-based worksheets are more effective than ethnomathematics-based worksheets in improving quantitative literacy and mathematical problem-solving skills in spatial geometry.

Keywords: *Ethnomathematics, Problem Solving, Quantitative Literacy, Realistic Mathematics Education*

INTRODUCTION

Quantitative literacy and mathematical problem-solving skills are two essential competencies that should be developed in secondary school mathematics education. Quantitative literacy is understood as the ability to understand, interpret, evaluate, and communicate quantitative information to generate

Received **: 2025-12-08**
Revised **: 2026-04-01**
Accepted **: 2026-04-09**

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well-reasoned judgments and decisions in various real-world situations [1], [2]. Mathematical problem-solving refers to the ability to use mathematical knowledge, strategies, techniques, and reasoning to solve non-routine problems systematically [3]. These two competencies are not only related to mastering procedures but also to connecting mathematical concepts to real-life contexts, choosing appropriate representations, interpreting results, and assessing the reasonableness of solutions. Therefore, strengthening quantitative literacy and mathematical problem-solving skills must be positioned as substantive goals of mathematics education, rather than merely byproducts of routine calculation practice.

The urgency of developing these two competencies aligns with international educational assessment frameworks. The [4] emphasizes that mathematical literacy requires students to formulate, apply, and interpret mathematics in various real-world contexts, and to utilize the results to make informed decisions as reflective 21st-century citizens. Thus, quality mathematics education must not stop at mastering formulas; it must also encourage students to analyze situations, identify the quantitative aspects of a problem, select relevant strategies, and explain the results logically. This framework demonstrates that quantitative literacy and mathematical problem-solving are two interrelated and equally fundamental competencies in contemporary mathematics education.

However, various indicators suggest that Indonesian students' performance in this area still requires serious attention. The 2022 PISA results show that Indonesian students' average mathematics score is 366, far below the OECD average of 472. Furthermore, only 18% of Indonesian students reached at least Level 2—the minimum level at which students begin to recognize how a simple situation can be represented mathematically and use that representation to solve basic contextual problems [1]. These data confirm that the majority of students still struggle to connect mathematical knowledge with real-world contexts, interpret quantitative information, and apply appropriate problem-solving strategies.

This finding aligns with various research results indicating that Indonesian students' ability to interpret quantitative information and solve contextual problems remains relatively low. [5] demonstrate that students' mathematical literacy in solving PISA-based problems remains inconsistent, with many students lacking consistency in reasoning, representation, and the application of concepts. This is also consistent with [6], who emphasize that low numeracy literacy is closely linked to students' difficulties in analyzing information, using symbols or numbers appropriately, and making mathematical decisions, particularly in geometry. This situation indicates that the challenges students face are not merely due to weak procedural skills but also stem from limitations in interpreting context, constructing models, selecting strategies, and interpreting results meaningfully.

These issues become increasingly significant when related to solid geometry. Solid geometry is a topic that demands visualization skills,

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abstraction, spatial reasoning, and the ability to connect mathematical shapes with real-world objects. In this topic, students are not only asked to calculate area or volume; they are also asked to calculate other quantities. However, they must also understand the relationships between geometric elements, interpret visual representations, and apply concepts to everyday situations. [6] indicate that geometry is one of the subjects that frequently pose difficulties because students struggle to visualize abstract objects and to translate contextual problems into mathematical models. On the other hand, a study by [7] indicates that geometry, including solid geometry, is one of the areas most closely associated with ethnomathematics in Indonesia because it intersects directly with shapes, patterns, structures, architecture, traditional games, and cultural artifacts. Therefore, solid geometry serves as a relevant context for developing and assessing quantitative literacy and mathematical problem-solving skills.

One approach to addressing this issue is to develop structured, contextually relevant, and student-centered instructional materials. In this regard, student worksheets (LKS) should not be viewed merely as practice tools but as pedagogical tools that systematically organize students' learning experiences. Through LKS, teachers can present contextual problems, guide students to identify key information, select visual or symbolic representations, design solution strategies, test the validity of results, and reflect on the thinking processes they have undertaken. In line with this, [8] demonstrate that numeracy-based instructional materials have the potential to support students' numeracy skills, while [9] affirm that activities in LKPDs connected to students' real-world experiences are effective in supporting numeracy skills through problem-solving tasks. Findings by [10] also indicate that contextual E-LKPDs have the potential to affect mathematical problem-solving abilities. Thus, worksheets possess a strong theoretical and empirical foundation for use as an intervention tool in the development of quantitative literacy and problem-solving skills.

Among the various approaches to designing contextual worksheets, Realistic Mathematics Education (RME) is one with a strong conceptual foundation. [11] views mathematics as a human activity; therefore, mathematics learning should provide students with opportunities to rediscover mathematical ideas through meaningful processes. In line with this, [12] emphasize that the main characteristics of RME lie in the use of rich, realistic situations as a starting point for learning, a gradual process of mathematization, the use of models, active student contributions, interactivity, and interconnections between concepts. Within this framework, context is not merely a decorative element of learning but a vehicle for bridging students' informal experiences toward more formal mathematical understanding.

Empirically, RME has also demonstrated positive effects on students' mathematical abilities. [13], in a meta-analysis of Indonesian studies, found that RME consistently improves students' mathematical abilities across levels. Meanwhile, [14]

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demonstrated that RME-based numeracy instruments with a maritime context are valid, practical, and effective for fostering numeracy skills through the integration of real-world contexts. These findings indicate that RME is relevant when learning objectives are directed5 toward progressively strengthening the ability to understand contexts, construct models, reason, and solve problems.

Another relevant approach is ethnomathematics. [15] view ethnomathematics as a way to examine and develop mathematical knowledge rooted in practice, experience, and cultural context. In learning, this approach creates space for students to interpret mathematics as knowledge alive in their environment, rather than as a concept detached from social and cultural reality. A study by [7] indicates that ethnomathematics research in Indonesia is growing rapidly, with geometry being the most frequently studied topic. The study also confirms that integrating culture into mathematics education can enhance the meaningfulness of learning, students' engagement with the material, and the relevance of learning experiences to their lives.

The effectiveness of the ethnomathematics approach in supporting mathematical abilities has also been widely reported. [16] demonstrated that ethnomathematics-based e-modules developed through an inquiry model are valid, practical, and effective in improving mathematical problem-solving skills. On the other hand, [17] demonstrated that RME-based learning with an ethnomathematics nuance is associated with the development of students' mathematical literacy. These findings indicate that cultural context not only fosters appreciation for local wisdom but can also serve as an effective medium for facilitating mathematical representation, reasoning, and problem-solving.

Based on this discussion, the selection of RME-based worksheets and ethnomathematics-based worksheets in this study has a clear comparative basis. Both types of worksheets stem from the contextual learning paradigm, position students as active agents in constructing knowledge, and provide space for meaningful problems, representations, discussions, and reflection. The difference lies in the source of the context used. RME-based worksheets rely on everyday realities that students can visualize and experience, whereas ethnomathematics-based worksheets rely on local cultural realities closely tied to students' social identities. Thus, both are worthy of comparison as they are pedagogically equivalent but differ in their contextual orientation.

This equivalence must be emphasized to ensure the comparison remains unbiased. In this study, both worksheets are positioned as equivalent tools in terms of spatial geometry content, learning objectives, achievement indicators, activity structure, and cognitive demands; thus, the primary focus of the comparison is on the contextual basis underpinning the learning activities. Additionally, the comparison is designed under controlled learning conditions by standardizing the content, time allocation, assessment format, and evaluation instruments. Clarification of these control variables is crucial for maintaining the internal validity of the study, ensuring that any differences in

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results can be more accurately interpreted as the influence of the approach underlying the worksheets rather than as due to differences in content or unequal treatment.

The simultaneous measurement of quantitative literacy and mathematical problem-solving skills in this study also has a strong foundation. Substantively, these two abilities are the learning outcomes most likely to be influenced by the use of contextual workbooks. Quantitative literacy is required when students read information, interpret data or measurements, choose representations, and connect computational results to situational meaning. Meanwhile, mathematical problem-solving skills are required when students identify problems, design strategies, construct models, carry out procedures, and evaluate solutions. In solid geometry content, these two competencies emerge simultaneously because students must engage with visual objects, measurements, spatial relationships, and contextual problems that demand step-by-step reasoning. Therefore, measuring both dependent variables simultaneously is not only relevant but also necessary to provide a more comprehensive picture of the effectiveness of the compared worksheets.

Although various studies have demonstrated the benefits of RME and ethnomathematics separately, there remains a gap in the literature for a direct comparison of these two approaches when implemented as equivalent worksheets and applied to solid geometry content at the high school level. Some studies focus more on the development of a single type of instructional material, the effectiveness of a specific approach, or the exploration of cultural contexts without placing them within a controlled comparative framework. In fact, the practical need in the field is not merely to know that a particular approach is effective, but also to understand which contextual approach is relatively stronger in facilitating quantitative literacy and mathematical problem-solving skills when applied to specific content.

Based on this background, this study aims to analyze the influence of using RME-based worksheets and ethnomathematics-based worksheets on students' quantitative literacy and mathematical problem-solving skills in solid geometry material at the high school level. This study is expected to provide a theoretical contribution by clarifying the relative positions of these two equally strong contextual approaches, while also offering practical guidance for teachers in selecting and designing instructional materials that are more appropriate, equitable, and meaningful for developing students' higher-order mathematical abilities.

METHOD

This study employed a quantitative, comparative quasi-experimental design. The design used was a posttest-only nonequivalent two-group approach to compare the effects of Realistic Mathematics-based Student Worksheets (LKS) and ethnomathematics-based Student Worksheets (LKS) on quantitative literacy and mathematical problem-solving in solid geometry.

The research instruments consisted of a quantitative literacy test and a mathematical problem-solving

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test. Prior to their use in the main study, both instruments were subjected to validity and reliability testing through a pilot study involving students with similar characteristics to the research sample.

The validity of the items was analyzed using the Pearson Product-Moment correlation. The results showed that all items in the quantitative literacy test had correlation coefficients ranging from 0.42 to 0.78, which exceeded the critical value $(r_{table} = 0.30)$, indicating that all items were valid. Similarly, the problem-solving test items had correlation coefficients ranging from 0.45 to 0.81, confirming that all items met the validity criteria.

In addition, item analysis was conducted to examine the level of difficulty and discrimination index. The results indicated that the items were distributed across moderate difficulty levels $(0.30 \leq p \leq 0.70)$ and had good discrimination indices $(0.30 \leq D \leq 0.70)$, meaning that the instruments were capable of distinguishing between high- and low-ability students effectively.

The reliability of the instruments was measured using Cronbach's Alpha. The quantitative literacy test obtained a reliability coefficient of 0.84, while the problem-solving test showed a coefficient of 0.87. These values indicate high internal consistency, suggesting that the instruments are reliable for measuring the intended constructs.Based on these results, it can be concluded that both instruments meet the criteria of validity and reliability and are therefore suitable for use in the main study.

This approach was chosen to compare the effects of two types of treatment (Realistic Mathematics-based worksheets and Ethnomathematics-based worksheets) on two dependent variables, namely quantitative literacy and problem-solving skills.

Table 1. Learning using Worksheet

Group	Learning using Worksheet	Measurement
Group A	Worksheets Based on Realistic Mathematics Education	*Posttest*
Group B	Worksheets Based on Realistic Ethnomathematics	*Posttest*

The sampling technique used in this study was cluster random sampling because the students were already organized into complete classes at each school. From each school, one 10th-grade class was selected using simple random sampling, ensuring that each class had an equal chance of being included in the study. All students in the selected classes were included as research subjects. Next, the sample classes were divided into two treatment groups: Group A $(n = 50)$ used worksheets based on Realistic Mathematics Education, and Group B (n = 50) used worksheets based on ethnomathematics. Before the treatments were administered, a pre-test was conducted based on previous mathematics achievement scores to ensure that both groups had relatively comparable initial abilities. The test results showed no statistically significant difference between the two

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groups ($p > 0.05$), so both were deemed suitable for further comparison.

During the implementation of the learning process, consistency was maintained across instructional materials, learning objectives, time allocation, learning steps, and the teachers involved, so that differences in learning outcomes would better reflect the influence of the workbook type used. The Realistic Mathematics Education (RME)-based worksheets were designed using real-life contexts as the starting point for learning. In contrast, the ethnomathematics-based worksheets were developed by integrating relevant local cultural contexts. Although they differed in their contextual approaches, both worksheets were structured similarly in terms of learning objectives, contextual problem formats, problem-solving activities, guiding questions, and learning reflections. Both workbooks are also designed to facilitate the development of quantitative literacy and mathematical problem-solving skills. Quantitative literacy is measured through the ability to identify relevant quantitative information, represent problems in mathematical form, use procedures or operations correctly, interpret results in context, and communicate conclusions logically. Problem-solving skills are measured by the ability to understand problems, plan solution strategies, implement solutions, and review results. After the learning intervention, both groups were given a posttest to measure these two abilities. The posttest results were then compared to assess the relative effectiveness of the two worksheet types. The research procedure flowchart is presented in Figure 1.

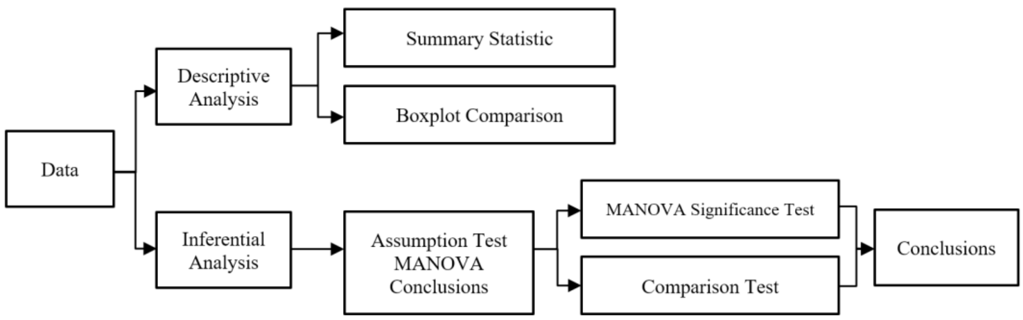

Figure 1. Research procedure flow

This study was conducted over six sessions, with worksheets used for each core learning activity in small groups, and learning outcomes were assessed individually through an essay test at the end of the intervention, yielding research data from each student’s post-test scores. The research instruments consisted of two types of worksheets and an essay test designed based on the indicators of both variables, which were then validated by experts and subject teachers before use. The research data were analyzed descriptively and inferentially using One-Way MANOVA because this study involved one categorical independent variable and two dependent variables analyzed simultaneously, after first satisfying

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the assumptions of multivariate normality, homogeneity of variances, and homogeneity of covariance matrices.

RESULT AND DISCUSSION

The characteristics of this research data can be seen from the descriptive statistics presented in the table 2.

Table 2. Descriptive statistics for the data used

Population	Independent Variable	Dependent Variable	Min	Max	Mean
Population A	Worksheet based on Realistic Mathematics Education	1. Quantitative literacy 2. Problem-solving skills	67 66	82 80	74,94 71,44
Population B	Worksheet based on Ethnomathematics	1. Quantitative literacy 2. Problem-solving skills	58 55	71 67	64,18 62,82

Based on the descriptive statistics in Table 2, a clear comparative advantage is observed for the Realistic Mathematics Education (RME) group. Students utilizing RME based worksheets (Group A) achieved higher mean scores in both quantitative literacy (74.94) and problem-solving skills (71.44) compared to their peers using ethnomathematics based worksheets (Group B), who scored lower in quantitative literacy (64.18) and problem-solving (62.82). This preliminary comparison indicates that the RME approach is more effective in initial outcomes. This aligns with the premise that effective teaching materials help students understand abstract concepts more concretely through visual and contextual approaches. The real-world situation involvement in RME appears to provide a stronger foundation for these competencies than the cultural integration approach alone, supporting previous findings that applying RME can significantly improve students' mathematical literacy and problem solving skills.

Normality test

The normality test for MANOVA can be performed in two stages, namely the multivariate normality test and the univariate normality test. The following are the results of testing the normality assumption using the Henze-Zirkler test.

Table 3. Normality Test

Test	Test Statistics	*P-value*
Henze-Zirkler Population 1	0,31	*0.87*
Henze-Zirkler Population 2	0.42	*0,62*

Table 3 shows the results of testing the assumption of multivariate normality. The initial hypothesis of multivariate normally distributed data and a significance level of 5% ($\alpha = 0.05$) leads to the conclusion that the data is multivariate normally distributed. This means that the

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assumption of multivariate normality is fulfilled. This conclusion is based on the p-value>α, which leads to the initial hypothesis being accepted.

Homoscedasticity Test

Two types of homoscedasticity tests can be performed, namely the test of variance homogeneity and the test of covariance matrix homogeneity. The following are the results of testing the assumption of homogeneity of variances using the Bartlett test.

Table 4. Results of the variance homogeneity test

Test	Variable	Test Statistics	*p-value*
Bartlett	Quantitative literacy	0,174	0,677
test	Problem-solving skills	0,671	0,413

Table 4 shows the results of the variance homogeneity test. Based on this table, with the initial hypothesis that the data variances are homogeneous and a significance level of 5% ($\alpha = 0.05$), it can be concluded that the variances for the quantitative literacy and problem-solving ability variables are homogeneous. This means that the assumption of homogeneity of variance is fulfilled for each dependent variable. This conclusion is based on the $p-value > \alpha$ test result, which indicates that the initial hypothesis is accepted. The results of the covariance matrix are shown in Table 5 below.

Table 5. Results of the covariance matrix homogeneity test

Uji	Statistik uji	*p-value*
$Box's\ M$	0,135	*0,1349*

The results of the test of covariance matrix homogeneity are shown in Table 6. The initial hypothesis of a homogeneous covariance matrix and a significance level of 5% ($\alpha = 0.05$) leads to the conclusion that the covariance matrix is homogeneous, since the $p-value > \alpha$ thus, the initial hypothesis is accepted. This means that the covariance matrix homogeneity assumption is fulfilled. Since all assumptions have been met, the MANOVA significance test can be performed.

Two Population Mean Test

The Two Population Mean Test was performed to determine whether the two populations had the same mean for quantitative literacy and problem-solving abilities. The following are the results of the Two Population Mean using Hotelling's t-test.

Table 6. Results of the Test of the Mean of Two Populations

Test	Test Statistic	Critical Value
Uji T Hotelling	393.05	6.25

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Based on Table 6, Hotelling's T statistic is 393.05, which exceeds the critical value of 6.25. This indicates a very significant multivariate difference between the worksheet-based realistic mathematics education and ethnomathematics in quantitative literacy and problem-solving skills.

One-Way MANOVA Test

The one-way MANOVA test was conducted to determine the significance of the influence of worksheet-based realistic mathematics education and ethnomathematics on quantitative literacy and problem-solving abilities as a whole. The following are the overall results of the one-way MANOVA test.

Table 7. Results of Manova One Way Test

Test	Test Statistic	Critical Value	P Value
Uji T Hotelling	393.05	6.25	1.13

Based on the table above, the one-way MANOVA test yielded a p-value of 1.134262 which is greater than the critical value of 3.09. This means that worksheet-based realistic mathematics education and ethnomathematics have a significant simultaneous effect on quantitative literacy and problem-solving skills.

Univariate Follow-up Test (ANOVA)

ANOVA for Quantitative Literacy Skills

The ANOVA test was conducted to assess the effect of worksheet-based realistic mathematics education and ethnomathematics on quantitative literacy skills. The following are the ANOVA results for quantitative literacy.

Table 8. ANOVA for Quantitative Literacy Skills

Source	SS	df	MS	F	P	Partial η^2
Inter-type Worksheet	2894.44	1	289.44	245.44	< 0.001	0.71
Internal Calculations	1028.20	98	10.50			
Total	3922.62	99	-			

Based on Table 8, there is a significant difference between the worksheet-based realistic mathematics education and ethnomathematics in quantitative literacy skills. The $F(1,98) = 245.44$ and $P < 0.001$ values indicate a very significant difference in the average quantitative literacy between the groups. The $\eta^2 = 0.71$ indicates a significant effect. Substantively, students who learned with worksheet-based realistic mathematics education showed higher quantitative literacy performance than those who learned with worksheet-based ethnomathematics.

ANOVA for Problem-Solving Ability

ANOVA testing was conducted to assess the effect of worksheet-based realistic mathematics education and ethnomathematics on problem-solving ability. The following are the ANOVA results for problem-solving ability.

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Table 9. ANOVA for Quantitative Problem-Solving Ability

Source	SS	df	MS	F	P	Partial η^2
Inter-type Worksheet	1857.61	1	1857.61	275.88	< 0.001	0.74
Internal Calculations	741.70	98	7.57	10.50		
Total	2599.31	99	-			

Based on Table 9, there is a significant difference between the worksheet based realistic mathematics education and ethnomathematics in problem-solving skills. The $F(1,98) = 275.88$ and $P < 0.001$ indicate a very significant difference in the average problem-solving ability between the groups. The $\eta^2 = 0.74$ indicates a significant effect. These findings confirm that the use of worksheet-based realistic mathematics education is associated with problem-solving achievements that are statistically and practically superior to those achieved with worksheet-based Ethnomathematics.

Consistently across both outcome variables, the type of worksheet had a strong influence on student achievement. The very small p-value together with the large partial η^2 indicates that the findings are not only statistically significant but also educationally relevant. Thus, the use of worksheet-based realistic mathematics education is recommended to improve quantitative literacy and problem-solving skills at the high school level, especially in spatial geometry.

CONCLUSION

All MANOVA assumptions were met, including multivariate normality (Henze–Zirkler test), homogeneous variance (Bartlett), and homogeneous intergroup covariance matrices (Box's M). With these assumptions met, multivariate analysis could proceed. Multivariate analysis revealed very significant differences between worksheets based on Realistic Mathematics Education (RME) and worksheets based on Ethnomathematics across the two outcomes (quantitative literacy and problem solving), both in Hotelling's T² $393 > 6.25$. and in a one-way MANOVA $194.52 > 3.09$. These findings confirm the simultaneous influence of worksheet type on student achievement. The univariate test confirmed that RME excelled in both with a significant effect Literacy Skills $particial\,\eta^2 = 0.74$ and *Problem-Solving Ability* $particial\,\eta^2 = 0.71$. Thus, worksheets based on Realistic Mathematics Education are more effective than worksheets based on Ethnomathematics in improving Literacy Skills and *Problem-Solving Ability* in spatial geometry material in high school. The application of eets based on Realistic Mathematics Education should be prioritized as a learning tool to improve quantitative literacy and problem-solving skills in the context of spatial geometry in high school.

ACKNOWLEDGMENTS

The authors would like to thank the teachers and principal of school for their access and support during the research process. We would also like to thank the students and teachers who participated in this research. This research was conducted independently without external funding or sponsorship.

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