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Application of Live Worksheet to Optimize Spatial Thinking Ability

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ABSTRAK

Kemampuan spasial matematis penting dalam membantu siswa memahami, menginterpretasikan, dan menyelesaikan masalah yang berkaitan dengan bentuk, ruang, dan hubungan antar objek. Namun, masih banyak siswa yang memiliki kemampuan spasial rendah. Penelitian ini bertujuan untuk meningkatkan kemampuan berpikir spasial siswa melalui media pembelajaran Live Worksheet. Metode yang digunakan adalah kuantitatif dengan desain quasi eksperimen one-group pretest-posttest. Subjek penelitian adalah 32 siswa kelas XII SMA Negeri 3 Sungai Penuh. Instrumen berupa soal pretest dan posttest dianalisis berdasarkan validitas, reliabilitas, tingkat kesukaran, dan daya beda. Peningkatan hasil belajar dianalisis menggunakan n-gain. Hasil menunjukkan rata-rata skor pretest sebesar 23,49 meningkat signifikan menjadi 91,61 pada posttest. Dengan demikian, penerapan Live Worksheet efektif dalam meningkatkan kemampuan berpikir spasial siswa.

Kata Kunci: E-LKPD; Kemampuan Spasial; *Live Worksheet;* Penerapan.

ABSTRACT

Mathematical spatial ability is important in helping students understand, interpret, and solve problems related to shapes, space, and relationships between objects. However, many students still have low spatial ability. This study aims to improve students' spatial thinking ability through the Live Worksheet learning media. The method used is quantitative with a one-group pretest-posttest quasi-experimental design. The subjects of the study were 32 students in grade XII at SMA Negeri 3 Sungai Penuh. The instruments consisted of pretest and posttest questions, which were analyzed based on validity, reliability, difficulty level, and discriminative power. Learning outcomes were analyzed using n-gain. The results showed that the average pretest score of 23.49 increased significantly to 91.61 in the posttest. Thus, the implementation of Live Worksheet is effective in improving students' spatial thinking skills.

Keywords: E-LKPD; Spatial Ability; Live Worksheet; Implementation.

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1. INTRODUCTION

Mathematics plays an important role in the advancement of education and technology (Mulyani F & Haliza N, 2021; Muhtadi, Wulandari, & Sukirwan, 2023). Although often considered difficult, math is useful in everyday life (Wulandari, Suwarto, & Novaliyosi, 2021; Adhiyati et al., 2022). By mastering mathematics, students' abilities can be improved (Maf' ulah et al., 2021; Wardani et al., 2024). The mathematical ability in mathematics that students need to master is spatial ability. This statement is reinforced by the opinion of Aliman et al., (2024) the development of abilities in the learning process is very important for students, one of which is the ability of students to think spatially.

Spatial ability is an ability that involves mental manipulation of visual stimuli and is closely related to the field of technology (Lubis et al., 2020) includes cognitive abilities related to understanding, processing, and rotation of visual objects (Leni et al., 2021; Aini & Suryowati, 2022). The results of research Rangkuti (2022) suggest that students who have mathematical abilities at high and medium levels are students who have good spatial abilities. Then another study also states that students who have *high* spatial abilities are more skilled in solving geometry problems based on *high order thinking* than students who have medium or low spatial abilities (Mahfuddin & Caswita, 2021; Ningsih et al., 2023; Vrasetya & Nasution, 2024). Then Anissa et al., (2022) also argue that high spatial ability is able to optimize student interest in learning, especially in geometry lessons.

Behind the advantages of this spatial thinking ability, but in fact many students with low levels of spatial ability. In line with the results of research conducted by Yulia and Putri (2024), indicates that the level of spatial ability of class X students in one high school is very low with the results of the analysis of 70% of students getting scores in the low category. Then a study in Balikpapan found low spatial thinking ability among high school students (Adzani et al., 2023). To overcome this, researchers suggest designing experiments focused on optimizing students' spatial abilities through mathematics education using technology-based media (Teapon & Kusumah, 2023). Factors that contribute to poor spatial ability include difficulties in spatial visualization and symbolic representation (Soraya et al., 2021).

This is based on the opinion of (Laswadi, 2022) regarding the results of the needs analysis revealed that students need mobile learning-based learning media that supports independent learning and is easily accessible, as well as valid and practical to use (Ningsih et al., 2021). Then according to Wahyuni and Hidayati (2020) that involving ICT media in learning can significantly affect spatial abilities. Likewise, the findings of Farihah (2023) specifically explain that *live worksheets* are able to optimize students' spatial thinking skills, more specifically in geography material. Next according to Bombang et al. (2022) argues that *Live worksheet* is considered very effective in optimizing student learning outcomes. According to Hamidah et al. (2024) which

conveys that the use of *Live Worksheet* is able to optimize student learning motivation in the material tangent to the circle, with an average percentage value of 76.9%, which reflects a significant influence.

With the previous opinion, therefore the researcher chose *Live Worksheet* media in optimizing spatial thinking ability on the arc and circumference of a circle material. This is also based on the limitations of research on the application of *Live Worksheet* on spatial abilities, especially on the arc and circumference of the circle material. Then reaffirmed by Pitriyani et al (2024) that the need for technology-based teaching media that can help students visualize objects as well as practical and easy to use to optimize students' mathematical spatial abilities. With the novelty that focuses on the effectiveness of *Live Worksheet* in optimizing students' spatial understanding of the arc and circumference of the circle material and against the background of limited research involving between spatial abilities and Live worksheet media. Therefore, the researcher hopes that this activity can achieve the goal of optimizing students' spatial thinking skills on the Arc and Juring of the Circle material by applying *Live Worksheet* and being able to become a reference for future research in terms of optimizing spatial abilities.

2. METHOD

This research was conducted from January 4 to January 22, 2025. Using a quantitative quasi-experimental method with a one-group pretest-posttest design (see Table 1). This design involves measuring the dependent variable before and after application in the same group, without using a control group (Hevtarani et al., 2024).

Table 1. One-Group Pretest-Posttest Design

Pretest	Treatment	Posttest
01	X	02

Description:

01 : Measurement of initial spatial thinking ability (*pretest*).

02 : Final spatial thinking ability measurement (*posttest*).

X : Giving Treatment (Learning based on *Live worksheet of* Arc and Juring Circle material)

This activity was carried out on one welding that was given treatment in the form of applying *live worksheets.* The sampling technique used Convenience Sampling technique which is a nonprobability sampling technique used when randomization is impractical, resources are limited, or generalization is not the main objective (Obilor a & Isaac, 2023). The research subjects were class XII students at SMA Negeri 3 Sungai Penuh. One class consisting of 32 students was used as the research sample. Data collection involved *pretest-posttest* test of spatial thinking ability and *Live Worksheet* as learning media. All instruments covering spatial thinking ability were prepared based on spatial thinking indicators relevant to the learning material. The indicators of

mathematical spatial thinking ability (see Table 2) of *Live Worksheet* students were adapted from (Harahap, 2020).

Table 2. Indicators of Spatial Understanding

No.	Spatial ability indicators
1	Identify the position between elements of an object.
2	Perceive and write down the shape or position of an object.
3	Give directions and present various geometry models drawn on a flat plane.
4	Calculate the original dimensions of a visual representation of a geometry object.

(Source: Adapted from Harahap, 2020)

Table 3. Criteria for Achieving Students' Spatial Ability

Percentage	Category
$0\% \leqslant p \leqslant 25\%$	Very low
$25\% < p \leqslant 50\%$	Low
$50\% < p \leqslant 75\%$	Medium
$75\% < p \leqslant 100\%$	High

Source: (Harahap, 2020)

In order for the question instrument to have good quality and validity to be applied to students, it is necessary to involve a test of difficulty level, differentiation test, validity and reliability (see Table 3). This question test aims to test the feasibility of the question before it is done by students so that activities can be carried out effectively (Fauzan et al., 2021). In addition, this evaluation allows educators to identify and revise poorly performing items, ultimately optimizing the overall quality of their assessment (Erita et al., 2022). Before this stage, the questions have been validated first by expert lecturers in mathematics.

The last stage is the use of the n-gain formula and the final score formula (see Table 4). The n-gain formula is used to measure the *pretest-posttest* comparison and measure the effectiveness of the application of Live worksheet in one of the XII classes in SMA Negeri 3 Sungai Penuh.

$$Normal\ Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Ideal - Skor\ Pretest}\ x\ 100$$

Table 4. N-Gain Score Criteria

N-Gain Index	Description
$g > 0{,}7$	High
$0{,}3 \leqslant g \leqslant 0{,}7$	Medium
$g < 0{,}3$	Low

Source: (Melzer, 2002)

After obtaining the n-gain value, calculations were carried out using the final value formula to obtain the n-gain effectiveness score (see Table 5). In addition, the final score formula

is involved in almost all formulas in this study to calculate the total score of students or the total score.

Table 5. N-Gain Effectiveness Criteria

Effectiveness Index	Description
<40	Ineffective
40 - 55	Less Effective
56 - 75	Effective Enough
>76	Effective

Source: (Hake, 1999)

This activity begins with analyzing *pretest* questions in classes that have the same level of understanding as the research subject class. The *pretest* questions were then given to students of class XII D. After conducting the *pretest*, the implementation of learning using *live worksheet-based* for 3 meetings was carried out. During the learning process, students were instructed to complete tasks on the E-LKPD interactively through a *live worksheet* platform designed to optimize visualization, interpretation, and spatial analysis skills. After the treatment was completed, a *posttest* was conducted to measure changes in student learning outcomes based on indicators of students' spatial thinking skills. The hypotheses tested are: 1) H_0: There is no significant influence between the use of Live Worksheet in optimizing the spatial thinking ability of class XII students at SMA Negeri 3 Sungai Penuh, and 2) H_1: There is a significant influence between the use of Live Worksheet in optimizing the spatial thinking ability of class XII students at SMA Negeri 3 Sungai Penuh. The results of this hypothesis are then obtained using the n-gain value test which will later present the results of the difference in student learning outcomes before application and after application.

With this research design and procedure, it is expected that valid conclusions can be obtained regarding the effectiveness of the application of live worksheets in optimizing spatial thinking skills while supporting students' interest in learning.

3. RESULT AND DISCUSSION

After conducting activities that lasted for 6 days regarding the Application of Live Worksheet to Optimize Spatial Thinking Ability, the results and discussion obtained can be presented as follows.

In the first meeting, the research began by testing the questions to measure the level of difficulty, testing the differential power, validity, and reliability of the questions that would be applied to the pretest and posttest. The results of the analysis of the level of difficulty, differentiation test, validity and reliability of the questions can be seen in Table 6 and Table 7.

Table 6. Results of the Analysis of Difficulty Level and Differentiability

Question Number	Difficulty Index	Distinguishing Power

	Value	Interpretation	Value	Interpretation
1	0.425	Medium	0.292	Simply
2	0.353	Medium	0.278	Simply
3	0.135	Medium	0.306	Simply
4	0.239	Medium	0.556	Good
5	0.405	Medium	0.444	Good

Based on the results of the analysis of the level of difficulty and differentiation displayed in Table 6, it was found that all the questions tested had a difficulty index in the medium category, with values ranging from 0.3185 to 0.4252. This indicates that the questions have an appropriate level of difficulty to effectively measure students' abilities. In addition, the results of the differentiation analysis show that questions number 1, 2, and 3 have differentiation in the sufficient category, while questions number 4 and 5 are in the good category. So, it can be concluded on the criteria for difficulty level and differentiation, all questions tested meet the criteria for use. Furthermore, the questions will be tested for validity and reliability. According to Qomariyah (2022) shows that the analysis of item difficulty and differentiating power contributes to the validity and reliability of the assessment as a whole, which ensures that the assessment measures students' cognitive abilities effectively.

Table 7. Validity and Reliability Test Analysis Results

Question Number	Validity		Reliability	
	T Count	Interpretation	Cronbach's Alpha	Interpretation
1	3.168	Valid		
2	2.663	Valid		
3	4.726	Valid	0.532	Reliable
4	7.034	Valid		
5	3.087	Valid		

Based on the analysis results in Table 7, it was found that the five items tested were valid and suitable for use. The validity of the question is indicated by the calculated T value which is greater than the T table (1.70) with an average of 4.14. These results are in line with research conducted by Erita et al. (2022), which obtained an average validity of 4.05, so it can be concluded that each question meets the validity criteria. In addition, the results of reliability analysis using the *Cronbach's Alpha* formula show a value of 0.5315, which indicates that the instrument has a fairly good reliability. This is in accordance with the statement of Utami et al. (2023), which states that reliability coefficients above 0.5 are generally considered acceptable. Based on the analysis of difficulty level, differentiation, validity, and reliability, it can be concluded that the five items tested have met the eligibility criteria for use in the *pretest* and *posttest*.

Table 8. Percentage of Students' Spatial Ability in the *Pretest*

Percentage	Category
64%	Very low
34%	Low
3%	Medium
0%	High

Based on Table 8, the results of the analysis of the initial problem work, it is known that the average spatial ability of students as a whole is 23.49%. This percentage is classified in the very low category, which indicates that most students still have difficulty in solving problems that require spatial thinking skills. This finding indicates that the majority of students still have limitations in spatial ability, which can affect their understanding of various concepts in subjects that require spatial thinking skills, such as math, geography and physics. In addition, the results of this study are in line with a study conducted by Adzani et al. (2023), which stated that the average spatial ability of students at the senior high school level tends to be in the low category.

After the pretest, the *application of the live worksheet* containing material about the arc and the circumference of a circle was carried out. This material is divided into three main parts, namely the length of the arc of a circle, the area of the circle's juring, and the relationship between the arc length and the area of the circle's juring. In each learning session, students are directed to first access the *live worksheet* as a learning media to understand the material to be learned. After the presentation of the material is complete, students are asked to work on interactive questions on the final page. Each question consists of various forms of exercises. After doing the exercise, the student's answer will be sent to the teacher's account and automatically graded and the value will also appear on the student's cellphone screen. This media can be accessed by students anywhere and anytime, and the *softfile* of this material can be downloaded by students to be stored *offline*.

Table 9. Percentage of Students' Spatial Ability in the *Posttest*

Percentage	Category
0%	Very low
3%	Low
16%	Medium
81%	High

On the last day of the study, students were instructed to do a *posttest* consisting of five questions. The questions in this posttest are designed with the same level of difficulty as the pretest questions, so that the results obtained can reflect the development of students' spatial abilities objectively after following a series of *Live Worksheet-based* learning. Based on Table 9, the overall average percentage of students' *posttest* results reached 91.61%, which is included in the high category. This shows that the majority of students have experienced significant

optimization in understanding and applying spatial concepts compared to the *pretest* results. This result is in line with the findings of previous research proposed by Zakirman and Aufiana (2023) and Bombang et al. (2022) , which states that the use of *Live Worksheet* in learning can significantly optimize students' mathematical abilities. In the context of this study, these results also prove that the *Live Worksheet-based* method not only has a positive impact on mathematics learning, but is also effective in optimizing students' spatial thinking skills. The following are the results of further analysis of students' spatial thinking skills based on each indicator of spatial thinking skills.

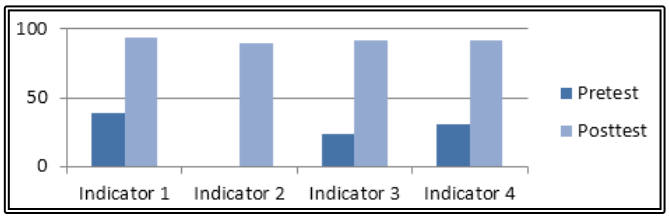

Figure 1. Analysis Results of Spatial Thinking Ability per Indicator

In Figure 1, it can be seen the comparison between the *pretest* and *posttest* results of students' spatial abilities analyzed based on each indicator. In this study, there are four main indicators used to measure students' spatial thinking skills adapted from Harahap's (2020). The first indicator tests students' ability to describe the position of an element or more briefly, identify known information from the problem. The second indicator measures students' ability to imagine and write the form of a position of objects or geometric shapes. The third indicator focuses on students' skills in presenting the geometry model of the problem or more specifically, determining the formula to be used. Finally, in the fourth indicator, students are asked to be able to calculate the actual size of a geometry form.

The results of the analysis showed that before being given intervention through *Live Worksheet-based* learning, students' spatial ability scores on the *pretest* were still relatively low. In the first indicator, only 38.8%, were able to fulfill this indicator. After that, the second indicator obtained the results of 0% of students who were able to meet this indicator, which means that all students have not been able to visualize and write the form of a geometric figure in the problem. Then the third indicator obtained a percentage of 24.2% of students who were able to fulfill this indicator. While the fourth indicator is at 31% in the low category. So it can be concluded that in the *pretest* the average ability of students to meet the indicators can be categorized in the very low category. However, after the intervention, the *posttest* results showed optimal results in all indicators. In the first indicator, there were 93.8% of students who were able to fulfill this indicator. Then in the second indicator, there were 89.8% of students. In the third indicator, there were 91.5% of students who were able to understand this indicator. Finally, the fourth indicator also increased to 91.5% who were able to explain this indicator. This optimal result proves that

on average all students are able to fulfill all the indicators needed in spatial thinking. These results are in line with Ghifari et al (2024) that using *live worksheets* can optimize student interest and learning outcomes. Then confirmed by Farihah (2023) that *live worksheets* are able to optimize students' spatial thinking skills, more specifically in geography material. To get a more detailed picture to test the hypothesis in this research, further analysis will be carried out using the N-Gain calculation to see the improvement of students' abilities both individually and as a whole.

N-Gain analysis is a method used to measure the effectiveness of learning interventions by comparing pre-test and post-test scores (Intan & Rosyid, 2020). N-gain analysis can reveal significant learning improvements in various subjects (Resesi et al., 2022). After the analysis, the results obtained can be seen in Table 10.

Table 10. N-Gain Analysis of Pretest and Posttest

Student Number	Pretest	Posttest	Difference	N Gain Score	Criteria
1	38.33	58.33	20	0.32	Medium
2	8.33	100	91.67	1	High
3	8.33	100	61.67	1	High
4	40	100	60	1	High
5	31.67	63.33	31.67	0.46	Medium
6	20	100	80	1	High
7	20	41.67	21.67	0.27	Low
8	46.67	100	53.33	1	High
9	20	100	80	1	High
10	26.67	100	73.33	1	High
11	15	61.67	46.67	0.55	Medium
12	25	100	75	1	High
13	25	100	75	1	High
14	15	100	85	1	High
15	41.67	100	58.33	1	High
16	28.33	100	71.67	1	High
17	16.67	100	83.33	1	High
18	15	100	85	1	High
19	51.67	100	48.33	1	High
20	28.33	100	71.67	1	High
21	13.33	100	86.67	1	High
22	10	50	40	0.44	Medium
23	0	56.67	56.67	0.57	Medium
24	15	100	85	1	High
25	25	100	75	1	High
26	20	100	80	1	High
27	10	100	90	1	High
28	10	100	90	1	High
29	25	100	75	1	High
30	10	100	90	1	High

Student Number	Pretest	Posttest	Difference	N Gain Score	Criteria
31	38.33	100	61.67	1	High
32	23.33	100	76.67	1	High
Mean	23.49	91.61	68.13	0.89	
Maximum Score	51.67	100	91.67	1	
Minimum Score	0	41.67	20	0.27	

Based on the Table 10, the average *pretest* score of students before the intervention was 23.49. After participating in *Live Worksheet-based* learning, there was a significant increase, where the average *posttest* score increased to 91.61, with an average difference of 68.13. This increase shows the effectiveness of using *Live Worksheet* in optimizing students' spatial thinking skills. This result is also in line with research conducted by (Astuti et al., 2021) , which found a significant increase in student test scores, with the average *posttest* increasing from 66.29 to 94.16 which indicates a drastic increase in student ability.

Furthermore, the results of individual score analysis showed that the highest *pretest* score achieved by students was 51.67, while the lowest score was 0. After the intervention, the highest posttest score reached 100, while the lowest score increased to 41.67. In addition, the average N-Gain calculation of 0.89 indicates a high improvement in students' spatial thinking skills. Of the total 32 students who participated in the study, 25 students or 78.1% improved in the high category, 5 students or 15.6% in the medium category, and 1 student or 3.1% in the low category.

Therefore, it can be concluded that the application of *Live Worksheet* in optimizing spatial thinking skills on Arc and Juring Circle material, is declared effective in optimizing the spatial thinking skills of 12th grade students at SMA Negeri 3 Sungai Penuh.

4. CONCLUSION

Based on the results of data analysis, this study shows that the application of Live Worksheet is effective in optimizing the spatial thinking skills of 12th grade students at SMA Negeri 3 Sungai Penuh. This is evidenced by the increase in the average score from the *pretest* of 23.49 to 91.61 on the *posttest*, with an average N-Gain of 0.89, which is categorized as a high improvement. Thus, the use of *Live Worksheet-based* not only improves students' learning outcomes but also motivates them to be more active in the learning process. This study recommends that this technology-based is applied more widely as an innovative learning media to optimize students' spatial thinking skills and learning interest.

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