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THE DEVELOPMENT OF OLYMPIAD ORIENTED MATHEMATICS WORKSHEETS TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS IN JUNIOR HIGH SCHOOL

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ABSTRACT

Critical thinking remains a major challenge in junior high school mathematics learning, particularly in solving non routine problems that require reasoning and justification. Although Olympiad type (OSN) problems have strong potential to cultivate higher order thinking, their integration into regular classroom materials is still limited. This study aimed to develop Olympiad oriented (OSN) mathematics worksheets (LKPD) to address the limited availability of learning materials that foster junior high school students' critical thinking skills, particularly in exponent topics, which are conceptually challenging and frequently tested in mathematics competitions. The Research used a Research and Development (R&D) approach with the ADDIE model (analysis, design, development, implementation, and evaluation). The worksheets were designed to scaffold and strengthen critical thinking through five indicators: interpretation, mathematization, analysis, explanation, and evaluation. The field implementation involved 29 eighth grade students at MTsS YIC Sudirman in the 2025/2026 academic year. Product quality was examined through expert validation and user responses (teacher and students), while effectiveness was evaluated using a pretest–posttest design and indicator level performance analysis. The results showed that the developed worksheets were valid, practical and effective for classroom use. Students' achievement increased from a pretest mean of 14.77 (SD = 2.69) to a posttest mean of 23.28 (SD = 3.18). Improvements were found across all critical thinking indicators, with the most notable gains in interpretation and mathematization, followed by analysis. However, explanation and especially evaluation still required further reinforcement. Therefore, future instructional design should incorporate more tasks that explicitly require students to justify their reasoning, critique alternative solutions, and reflect on the validity of their answers to strengthen these higher order thinking components. Overall, the OSN oriented worksheets are valid, practical and effective improve students' critical thinking skills in junior high school mathematics learning.

Keywords: Olympiad Oriented Worksheets, ADDIE, Critical Thinking, Junior High School, Mathematics.

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PRELIMINARY

Critical thinking has become a primary demand in mathematics learning at the junior high school level. As a key 21st century competence, it directly relates to students' ability to analyze information and make decisions based on logical, mathematical reasoning (Zhou

dkk., 2025). In mathematics, critical thinking encompasses not only arriving at the final answer but also understanding problems, constructing arguments, and systematically reflecting on solutions (Utomo & Hardini, 2023). Therefore, instructional strategies should prioritize strengthening higher order cognitive skills that go beyond procedural mastery to foster critical thinking.

Empirically, Indonesian students' low critical thinking skills are reflected in international assessment results. In the Programme for International Student Assessment (PISA) 2022, Indonesia's mathematics score was 366, while the OECD average was 472 (OECD, 2023). Moreover, fewer than 5% of Indonesian students reached Level 4 and above, which requires reasoning, justification, and non routine problem solving. In contrast, the proportion of students at Levels 5–6, representing higher level critical thinking, was around 1%. These data confirm that junior high school mathematics instruction has not optimally developed the analytical and evaluative skills at the core of critical thinking.

These national assessment results may be closely related to classroom practices. Mathematics instruction in Indonesia is still largely dominated by routine exercises oriented toward obtaining final answers. Such practices provide limited opportunities for students to explain reasoning, explore alternative strategies, and construct conceptual connections when solving problems (Sarwanto dkk., 2020). Empirical studies further indicate that while students tend to perform adequately on procedural tasks, they experience significant difficulties when confronted with non routine problems requiring analysis and justification (Negara dkk., 2024). Consequently, the dominance of procedural instruction restricts students' opportunities to develop analytical reasoning and mathematical communication skills, particularly when confronted with non routine tasks.

One significant limitation lies in the characteristics of the learning materials used in classrooms. Student worksheets (LKPD) commonly employed in many schools primarily consist of structured, procedural exercises that focus on applying formulas and obtaining correct final answers. They rarely include non routine problems, open ended tasks, or prompts that require students to justify reasoning, compare alternative strategies, or reflect on solution validity (Maharani dkk., 2022). This condition contrasts with the national curriculum, which emphasizes the development of higher order thinking skills through challenging and meaningful learning activities (Susanto & Hapudin, 2024). The mismatch between curriculum expectations and the characteristics of existing worksheets restricts students' exposure to deep reasoning and analytical problem solving.

Problems presented in the National Science Olympiad (OSN) reflect characteristics of non routine mathematical tasks that require advanced reasoning processes. According to higher order thinking theory, non routine problems demand analysis, strategy formulation, model construction, and justification rather than mere procedural application (Rahman & Rusnayati, 2021). Such tasks align with the conception of critical thinking as a process involving interpretation, evaluation, and reflective reasoning in complex situations. Therefore, the structure of OSN problems provides a meaningful context for fostering students' analytical and evaluative capacities in mathematics learnin (Afifah dkk., 2023). Research shows that students familiar with OSN type problems tend to think more analytically, although they may still need improvement in evaluation and exploring alternative strategies (Jatmiko dkk., 2020). This highlights the potential of OSN contexts as a valuable resource for instructional design aimed at cultivating critical thinking in classroom settings.

However, in schools, OSN is generally positioned as an elite competition for a small group of students. Studies show that the use of OSN in regular learning remains limited, often focusing on policy aspects or coaching competition participants (Pattipeilohy dkk., 2024). In fact, OSN has pedagogical potential for adaptation into learning materials accessible to all students. Transforming OSN from a competitive context into a source of instructional inspiration requires developing structured, context specific learning tools.

OSN oriented LKPD can serve as an alternative learning Material that bridges curriculum demands and the nature of challenging problems. This type of worksheet is designed not merely as a practice sheet, but as an active learning tool that guides students to interpret problems, analyze information, develop strategies, and evaluate the results of their solutions (Sutama dkk., 2022). Comparisons between conventional LKPD and OSN based LKPD show significant differences in the quality of thinking processes fostered, particularly in critical thinking and mathematical communication (Muskita dkk., 2020).

Various LKPD development studies have reported positive effects on students' critical thinking. Worksheets based on higher order thinking skills (HOTS), inquiry, and multi representation have demonstrated high levels of validity and practicality and have moderately improved critical thinking outcomes (Net dkk., 2023). However, most previous studies have not specifically integrated the characteristics of OSN problems into mathematics worksheets for regular classroom use. In addition, critical thinking assessment is often conducted partially, without systematically analyzing students' thinking processes across comprehensive indicators.

In the context of MTsS YIC Sudirman, participation in the OSN event has been limited to a small group of selected students, and preparation activities have primarily focused on competition coaching rather than classroom integration. As a result, the majority of students have had minimal exposure to non routine, Olympiad type problems.

This study offers novelty by transforming OSN problem characteristics into structured learning worksheets that are accessible to all students, not only competition participants. Furthermore, it employs an indicator based analysis framework to systematically examine students' critical thinking processes. Thus, the research contributes not only to worksheet development but also to early preparation for broader student participation in OSN through inclusive instructional design.

METHODS

This study employed a Research and Development (R&D) approach using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The analysis stage involved identifying students' needs, examining the characteristics of OSN type problems, and analyzing the gaps in existing worksheets. The design stage focused on preparing the LKPD framework, integrating OSN characteristics, and constructing critical thinking indicators and assessment instruments.

The development stage included expert validation to assess the content, construct, and language validity of the LKPD. Revisions were made based on validators' suggestions. The implementation stage involved limited trials with 29 students to examine the practicality and initial effectiveness of the product. Practicality was analyzed through student and teacher response questionnaires, while effectiveness was evaluated through pre test and post test results on critical thinking indicators. Finally, the evaluation stage was conducted to analyze overall findings and refine the product based on trial results. The ADDIE model was selected because it provides a systematic pathway for developing instructional materials through iterative validation, try outs, and continuous evaluation to ensure product quality. The product developed in this study was an Olympiad oriented (OSN) mathematics student worksheet (LKPD) designed to analyze junior high school students' critical thinking skills. The ADDIE sequence is presented visually in Figure 1:

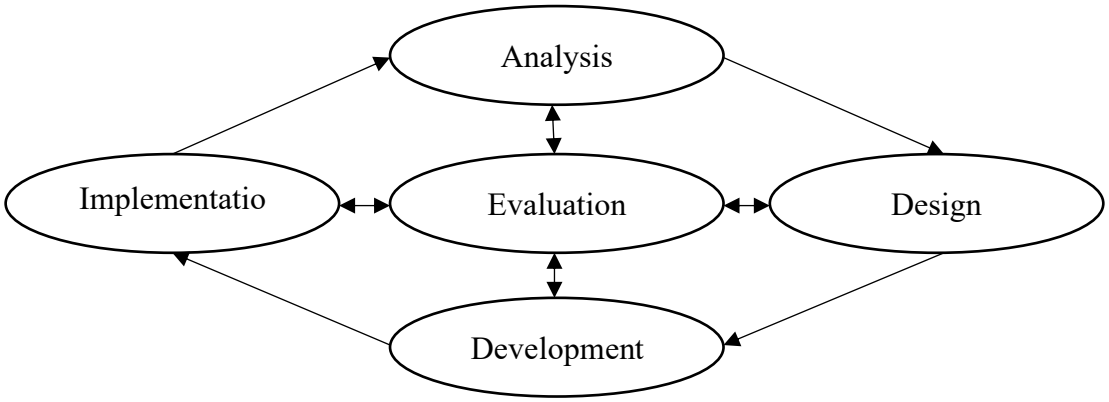


Figure 1. ADDIE Design
Source: Oktarina (2022)

The analysis stage was conducted through curriculum analysis, learner characteristics analysis, and OSN problem analysis. Curriculum analysis focused on aligning junior high school mathematics learning outcomes and objectives with the demands of critical thinking. Learner characteristics analysis examined students' learning habits, prior knowledge, and tendencies in solving non routine problems. OSN problem analysis was carried out by reviewing recent junior high school mathematics OSN problems to identify problem characteristics, thinking process demands, and their alignment with critical thinking indicators.

The design stage included designing the LKPD structure, mapping critical thinking indicators, and constructing Research instruments. The LKPD was designed to include non routine OSN type tasks that require students to interpret, perform mathematical modeling, conduct strategic analysis, explain, and evaluate results. The Research instruments developed included expert validation sheets, LKPD feasibility questionnaires, and pretest–posttest instruments to measure students' critical thinking skills.

The development stage involved drafting the LKPD based on the outputs of the analysis and design stages, followed by expert validation. The validation results served as the basis for revising the LKPD. Revisions were made iteratively until the LKPD was declared valid and feasible for classroom try out in the next stage.

The implementation stage consisted of a field try out and the administration of a pretest and a posttest. The try out involved all students in one class. During this stage, students worked on the LKPD individually or in groups and completed the pretest–posttest tasks. Students' written work was then analyzed to identify their attainment of the targeted critical thinking indicators.

The evaluation stage aimed to assess the final quality of the LKPD and analyze the potential effect of its use on students' critical thinking skills. Data were analyzed using descriptive quantitative and qualitative approaches. Valid, practical and effective data were analyzed using mean scores, while students' critical thinking performance was analyzed based on the distribution of indicator attainment, namely interpretation, mathematization, analysis, explanation, and evaluation. The findings were used to draw conclusions and generate recommendations for further development.

RESULT AND DISCUSSION

Analysis

At the analysis stage, the study focused on four main components: (1) student characteristics analysis, (2) learning needs analysis, (3) competency and content analysis, and (4) analysis of OSN problem characteristics. This analysis served as the conceptual basis for designing an OSN oriented mathematics LKPD explicitly intended to analyze junior high school students' critical thinking skills.

Student Characteristics Analysis

The analysis of Grade VIII students at MTsS YIC Sudirman showed that their critical thinking and mathematical communication skills remained low and uneven. Based on interviews and an initial questionnaire, about 83% of students reported memorizing formulas when solving exponent problems, without understanding the underlying concepts. In addition, 66% of students reported difficulty using mathematical symbols and terms accurately in written solutions, and they were more accustomed to writing only the final answer rather than explaining solution steps in an orderly, logical way.

These findings were reinforced by an analysis of students' initial achievement: around 36% were in the low category, 25% in the medium category, and only 39% in the high category. This distribution indicates that most students did not consistently demonstrate higher order thinking skills, especially when faced with problems requiring analysis, strategy evaluation, and non procedural reasoning. This condition reflects a gap between students' initial abilities and OSN type problem demands that emphasize mathematical argumentation and justification.

Table 1. Student Characteristics Analysis

Analyzed Aspect	Key Findings	Academic Indication
Problem solving strategy	83% of students tend to memorize formulas	LOTS dominant, minimal analysis

Analyzed Aspect	Key Findings	Academic Indication
Use of symbols & terminology	66% have difficulty using mathematical notation accurately	Weak in interpretation and explanation
Writing solution steps	Most students write only the final answer	Limited justification and reasoning
Argumentation about answers	Students are rarely asked to refute/evaluate peers' solutions	Evaluation indicator not yet developed
Attitude toward challenging problems	Tend to be afraid, but want to improve	Development potential if properly facilitated

Learning Needs Analysis

Learning needs were identified through teacher and student interviews and a review of the learning materials used in class. The results showed that the LKPD currently in use had not been systematically designed to cultivate critical thinking; rather, it primarily served as procedural practice. Activities were generally single step, oriented toward final answers, and provided minimal space for students to write reasons, compare strategies, or reflect on solutions.

The teacher stated a need for more operational, ready to use learning materials especially LKPD that can support Kurikulum Merdeka demands and non routine problems comparable to OSN. Meanwhile, students expressed interest in improving their ability to explain their reasoning and think critically in mathematics, though they still tended to feel anxious when confronted with perceived difficult problems.

Competency and Content Analysis

Competency analysis was conducted on junior high school mathematics learning outcomes and the characteristics of exponent content. This topic was selected because it has strong conceptual connections, clear potential for OSN context integration, and requires critical thinking to connect rules, patterns, and mathematical representations.

The analysis indicated that exponents require not only procedural mastery but also the ability to interpret information, analyze relationships among concepts, evaluate solution strategies, and explain mathematical reasoning in writing. Therefore, this topic was considered appropriate as the main context for developing an OSN oriented LKPD to analyze junior high school students' critical thinking skills.

OSN Problem Characteristics Analysis

OSN problems were analyzed by reviewing junior high school OSN mathematics problems on exponents from recent years. The analysis showed that OSN problems are non

routine, allow multiple strategies, and require high level reasoning especially during analysis and solution evaluation. Students must identify relevant information, construct mathematical models, consider alternative strategies, and critically evaluate the validity of results. This became the basis for designing LKPD activities that deliberately integrate OSN type tasks to stimulate each critical thinking indicator explicitly not merely as practice items, but as a means to analyze students' thinking processes.

Design

The Design stage of the ADDIE model focused on structuring the OSN oriented LKPD as a conceptually and visually organized instructional product. At this stage, the product identity was deliberately formulated to emphasize its Olympiad orientation, as reflected in the cover title OSN Oriented Worksheet: Exponents for Junior High School (Phase D). The cover design was arranged with a clear visual hierarchy highlighting the subject focus, grade level, and academic identity to reinforce its competition based character.

In terms of structure, the LKPD was designed to begin with learning outcomes, mathematical communication indicators, and critical thinking indicators, followed by conceptual introduction, guided exercises, and progressively challenging tasks. The section titled OSN Style Problem Solving marks the transition toward non routine Olympiad type problems. These tasks were intentionally constructed to include pattern generalization, exponential modeling, geometric scaling, digit pattern analysis, and structured mathematical reasoning.

Each problem layout was organized with sequential prompts such as determine, express, and explain, accompanied by extended reasoning spaces to ensure that students articulate interpretation, mathematization, analysis, explanation, and evaluation explicitly within the problem solving process. Thus, the Design stage established not only the content structure but also a pedagogical and visual framework aligned with Olympiad standards and higher order thinking development. The visual realization of this structured design is presented in Figure 2.

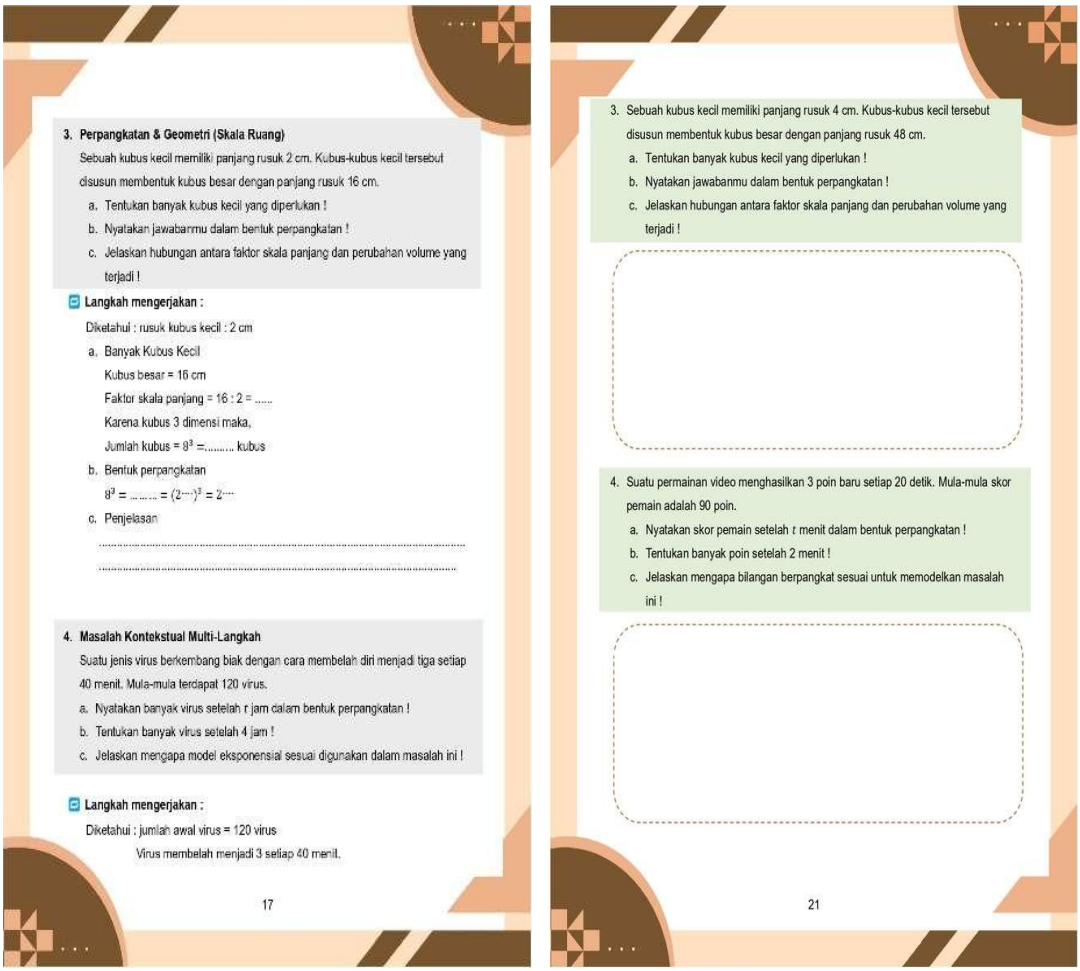


Figure 2. Design of Worksheet

As illustrated in Figure 2, each task is framed within a structured problem box and includes multi step instructions that guide students from interpreting contextual information to constructing mathematical models and justifying solutions. The inclusion of extended answer spaces and explicit reasoning prompts reflects the deliberate integration of OSN characteristics into the worksheet interface. This visual and structural design ensures that students' critical thinking processes become observable and measurable during classroom implementation.

Development

The Development stage translated the structured design framework into a complete and classroom ready OSN oriented LKPD. All conceptual and visual blueprints established in the Design stage were realized into a printed worksheet containing systematically organized sections, non routine Olympiad type tasks, and explicitly structured reasoning spaces. The layout elements described previously such as sequential prompts, extended answer areas, and progressive cognitive demand did not emphasize inferential statistics were

fully implemented to ensure alignment between design intentions and instructional execution.

At this stage, the LKPD was refined to ensure that each task explicitly corresponded to the five targeted critical thinking indicators: interpretation, mathematization, analysis, explanation, and evaluation. Particular attention was given to strengthening the evaluation component by adding reflective prompts and clearer instructions that required students to justify the validity of their solutions. Thus, the Development stage ensured that the pedagogical and visual framework established during Design was not merely conceptual, but operational and measurable in practice.

Expert validation was subsequently conducted to assess content accuracy, alignment with OSN characteristics, clarity of language, and coherence between task structure and critical thinking indicators. Based on validators' feedback, revisions were made to clarify wording, strengthen contextual–mathematical connections, and enhance reflection components. The final output of this stage was a validated OSN oriented mathematics LKPD that was ready for classroom implementation.

After the initial LKPD draft was completed, expert validation was conducted to evaluate content suitability, OSN problem characteristics, language clarity, alignment of activities with critical thinking indicators, and overall feasibility as a learning tool. The validation results indicated that the LKPD was valid, suggesting that the content aligned with curriculum demands, mathematics learning principles, and OSN characteristics.

Validators provided constructive feedback focused on improving the LKPD's academic quality. Key suggestions included clarifying item wording to avoid multiple interpretations, strengthening the link between context and mathematical modeling, and emphasizing reflection sections to encourage students to evaluate their solutions. Validators also highlighted the importance of consistent mathematical terminology and symbols that align with formal conventions and support student understanding.

Based on this feedback, revisions were made by improving problem formulations, clarifying instructions for each activity, and adding brief guidance to help students express mathematical reasons and justification in writing. Revisions also ensured that every activity explicitly corresponded to the targeted critical thinking indicators, especially evaluation, which was identified as the weakest indicator in students' initial abilities.

The final output of the development stage was an OSN oriented mathematics LKPD that had been valid, practical and effective for implementation. The LKPD not only met the content and presentation feasibility criteria but was also deliberately designed to facilitate

and reveal students' critical thinking processes through non routine problem solving. Thus, the development stage served as a crucial bridge between conceptual design and real classroom use.

Implementation

The implementation stage was conducted after the OSN oriented LKPD was validated in the Development phase. This stage aimed to examine the worksheet's practicality and effectiveness through classroom application. The trial involved 29 Grade VIII students at MTsS YIC Sudirman during the 2025/2026 academic year. Students first completed a pretest on non routine exponent problems, followed by learning activities using the structured OSN oriented LKPD. The intervention concluded with a posttest to measure improvement in critical thinking performance.

Following the learning intervention, the practicality of the OSN oriented LKPD was examined through student and teacher response questionnaires administered at the end of the implementation. The responses were converted into percentage scores to determine the operational feasibility of the worksheet in classroom practice.

Table 2. Practicality Criteria of the Developed LKPD

Test	Mean
00.00% – 20.00%	Very Impractical
20.01% – 40.00%	Impractical
40.01% – 60.00%	Less Practical
60.01% – 80.00%	Practical
80.01% – 100%	Very Practical

The categorization followed standard percentage based feasibility criteria commonly applied in instructional development studies.

Table 3. Summary of Student and Teacher Responses

Respondent	Mean Score	Percentage	Category
Students	2.79	69.83%	Practical
Teacher	3.20	80.00%	Practical

The practicality results are presented in Table 4. Students obtained a mean response of 69.83%, categorized as Practical, while the teacher response reached 80.00%, categorized as Practical. These findings indicate that the LKPD was feasible and manageable for classroom implementation.

The positive responses reflect that the worksheet instructions were clear, the task progression was systematic, and the reasoning spaces were adequate for students' written explanations. Therefore, the OSN oriented LKPD can be considered practically suitable for supporting structured critical thinking activities in mathematics learning.

In addition to practicality, the effectiveness of the LKPD was examined through a pretest–posttest comparison. Students' scores before and after the intervention were analyzed to determine the extent of improvement in critical thinking performance on non routine exponent problems.

Table 4. Practicality Criteria of the Developed LKPD

Gain Score (g)	Interpretation
$-1.00 \leq g < 0.00$	Decrease Occurred
$g = 0.00$	No Improvement
$0.00 < g < 0.30$	Low
$0.30 \leq g < 0.70$	Moderate
$0.70 \leq g < 1.00$	High

The normalized gain (N gain) was calculated to measure the degree of improvement, and the interpretation followed the criteria presented in Table 6.

Table 5. Summary of Pretest and Posttest Scores

Test	Mean	SD
Pretest	14.77	2.69
Posttest	23.28	3.18

The mean pretest score was 14.77, while the posttest mean increased to 23.28, indicating substantial improvement. The calculated normalized gain (N gain) was 0.56, which falls within the Moderate category ($0.30 \leq g < 0.70$). This result suggests that the OSN oriented LKPD contributed meaningfully to the development of students' critical thinking skills, particularly in facilitating measurable progress beyond initial performance levels.

Table 6. Students' Critical Thinking Indicator Profile

Indicator	Mean (Pretest)	Mean (Posttest)	Improvement Category
Interpretation	2.15	3.35	Moderate
Mathematization	2.12	3.32	Moderate
Analysis	1.93	2.86	Moderate
Explanation	1.60	2.41	Moderate
Evaluation	1.28	2.42	Moderate

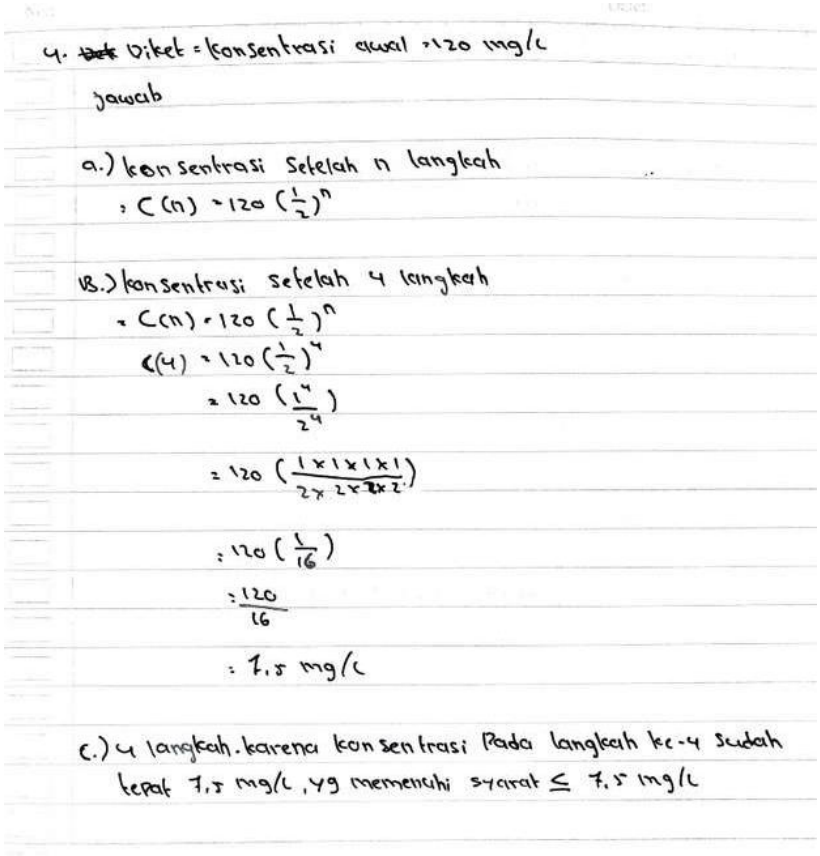
This increase in the mean score was supported by a difference test, which indicated that posttest scores were significantly higher than pretest scores. This suggests that the OSN oriented LKPD facilitated improvements in students' performance on non routine problems requiring reasoning. Although a pretest posttest comparison was conducted to observe score differences, this study did not emphasize broader inferential statistical generalization. This is because the research was conducted within a Research and Development framework, which primarily focuses on product development and feasibility testing rather than hypothesis testing. The field trial involved a limited sample of 29 students and did not

include a control group. Therefore, the quantitative results are intended to provide preliminary evidence of improvement within the trial group rather than to establish causal conclusions or population level generalization.

From the perspective of critical thinking indicators, improvements were not evenly distributed across indicators. Interpretation and mathematization improved most noticeably, reflected in students' ability to identify essential information and convert problem situations into exponent based mathematical models. Analysis also improved, particularly when students were asked to compare strategies and connect relevant concepts.

In contrast, explanation and evaluation showed more moderate improvements. Some students still struggled to produce coherent mathematical explanations and strong justification for chosen strategies. The ability to evaluate solutions and re check the reasonableness of results also did not consistently appear without explicit teacher guidance. This aligns with the initial analysis, which showed that evaluation was the weakest critical thinking indicator at baseline.

To complement the quantitative findings, qualitative evidence from students' written responses was analyzed. This analysis aimed to identify observable changes in reasoning structure and justification quality after the implementation of the OSN oriented LKPD.


4. Diket : konsentrasi awal = 120 mg/L

Jawab

a.) konsentrasi setelah n langkah

$C(n) = 120\left(\frac{1}{2}\right)^n$

B.) konsentrasi setelah 4 langkah

$C(n) = 120\left(\frac{1}{2}\right)^n$

$C(4) = 120\left(\frac{1}{2}\right)^4$

$= 120\left(\frac{1^4}{2^4}\right)$

$= 120\left(\frac{1\times1\times1\times1}{2\times2\times2\times2}\right)$

$= 120\left(\frac{1}{16}\right)$

$= \frac{120}{16}$

$= 7{,}5$ mg/L

c.) 4 langkah. karena konsentrasi pada langkah ke-4 sudah tepat 7,5 mg/L, yg memenuhi syarat $\leq$ 7,5 mg/L

Figure 3. Student Answer Sheet

As illustrated in Figure 3, the student's posttest response demonstrates explicit mathematical modeling, sequential reasoning, and written justification. Unlike typical pretest responses that often contained only final answers, the posttest work shows structured explanation and evaluation of the solution.

The presence of clearly written steps, correct exponential representation, and reflective verification indicates improvement particularly in the explanation and evaluation indicators. This qualitative evidence confirms that the LKPD facilitated not only score improvement but also deeper development of higher order thinking processes.

Overall, the implementation stage indicates that the OSN oriented LKPD for mathematics can be effectively applied in junior high school mathematics instruction. Achievement data, critical thinking indicator profiles, and user responses suggest that the LKPD supports students' critical thinking processes.

Evaluation

There are still aspects of the LKPD that require evaluation following implementation. During the evaluation phase, the product underwent final adjustments based on suggestions and user and student feedback from the implementation stage. Although students accepted the resulting worksheet well, some student feedback still needs to be addressed through additional instructional interventions.

Discussion

The implementation results show that the OSN oriented LKPD can foster students' higher order thinking engagement with exponents. Posttest scores were higher than pretest scores. This difference reinforces the idea that non routine activities requiring reasoning and justification give students room to construct strategies rather than merely repeat procedures. This aligns with evidence that worksheets designed with a HOTS orientation and developed through the ADDIE stages tend to meet feasibility criteria and improve student outcomes, particularly when learning activities scaffold thinking processes step by step (Sutarni dkk., 2024).

In terms of product quality, the LKPD was judged valid by experts and practical by users. In other words, the Material is not only correct in content but also workable in real classroom settings. The LKPD structure, which guides thinking steps, provides space for students' work, and offers reflective prompts, made the learning process more focused and organized. This is consistent with studies on worksheet development, which position validity and practicality as prerequisites for evaluating instructional impact. Practical worksheets help teachers function as facilitators and increase student participation (Widodo dkk., 2025).

When viewed through the lens of critical thinking indicators, the strongest gains occurred in interpretation and mathematization. This suggests that students learn more quickly when they are required to extract key information and convert it into mathematical models. In contrast, explanation, especially evaluation, remained challenging. Students were not yet consistent in writing coherent, sequential reasoning or in judging the reasonableness of their results. This pattern matches findings that mathematization often serves as a strong early bridge for understanding and solving problems. In contrast, the quality of argumentation and proof/solution appraisal requires explicit and repeated practice (Putri dkk., 2023).

The characteristics of OSN problems contributed substantially to this pattern. Non routine tasks typically allow multiple strategies and force students to decide under which conditions analysis and evaluation should proceed. However, in practice, students who are not accustomed to such tasks tend to stop at the first strategy that appears correct. They rarely re check their work or compare alternative approaches. This finding is consistent with studies that emphasize that non routine problems offer strong opportunities for strategic flexibility. However, success is strongly influenced by students' habits of checking and reflecting on solutions (Keleş & Yazgan, 2025). Future research is recommended to design learning interventions that explicitly train students in reflective and evaluative thinking, such as structured self checking prompts, mandatory comparison of multiple solution strategies, and metacognitive scaffolding embedded within non routine tasks. In addition, experimental studies involving control groups and larger samples are needed to examine whether such enhancements significantly strengthen students' evaluation skills and strategic flexibility in solving Olympiad type problems.

CONCLUSION

This study developed an OSN oriented mathematics worksheet (LKPD) on exponents for junior high school students, using the ADDIE model. The product was produced through the stages of needs analysis, design, development, implementation, and evaluation. The LKPD was constructed to guide and reveal students' critical thinking through five indicators: interpretation, mathematization, analysis, explanation, and evaluation.

Expert appraisal showed that the developed LKPD met the validity criteria. This means the mathematical content, OSN problem characteristics, language clarity, and alignment of activities with the critical thinking indicators were judged feasible both

conceptually and pedagogically. In addition, user responses indicated that the LKPD was practical for classroom use. Students reported that the LKPD was followable and helped them write down their thinking processes, while the teacher stated that the LKPD supported lesson implementation and increased student engagement.

The LKPD's effectiveness was reflected in the improvement from pretest to posttest. Indicator level analysis showed gains across all aspects of critical thinking. The most prominent improvements appeared in interpretation and mathematization, followed by analysis. Meanwhile, explanation, especially evaluation, still requires reinforcement. Students were not always consistent in writing mathematical reasons in a coherent sequence and in checking the reasonableness of their results without explicit guidance. Therefore, the developed OSN oriented LKPD can be considered valid, practical, and effective as both an instructional tool and a means to analyze junior high school students' critical thinking skills.

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