



Development of experiment-based worksheet to improve critical thinking in human respiration

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ABSTRACT

Limited student engagement and underdeveloped critical thinking skills in elementary science learning prompted the development of an experiment-based student worksheet on the topic of the human respiratory system. This study aimed to produce a valid, practical, and effective instructional tool for fifth-grade learners. The development process employed a modified ADDIE model consisting of analysis, design, development, implementation, and evaluation stages. Validation involved subject matter experts, media specialists, and language experts. Implementation engaged classroom teachers and students in assessing the practicality and effectiveness of the worksheet. Findings revealed that the worksheet content aligned with learning objectives, the visual presentation was appealing, and the language was clear and appropriate for elementary students. The evaluation process indicated that the product supported a more contextual and participative learning environment. Feedback from both teachers and students affirmed the worksheet's role in promoting critical thinking skills through well-structured experimental tasks. The overall quality of the worksheet demonstrated its potential as a relevant and meaningful learning medium that aligns with the principles of the Merdeka Curriculum in primary education.

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ABSTRAK

Rendahnya keterlibatan aktif peserta didik dan belum optimalnya keterampilan berpikir kritis dalam pembelajaran IPAS menjadi dasar pengembangan Lembar Kerja Peserta Didik (LKPD) berbasis eksperimen pada materi sistem pernapasan manusia. Penelitian ini bertujuan menghasilkan perangkat pembelajaran yang valid, praktis, dan efektif digunakan oleh peserta didik kelas V Sekolah Dasar. Proses pengembangan mengikuti model ADDIE yang dimodifikasi melalui tahapan analisis, desain, pengembangan, implementasi, dan evaluasi. Validasi produk dilakukan oleh ahli materi, ahli media, dan ahli bahasa. Implementasi melibatkan guru serta peserta didik untuk menilai kepraktisan dan efektivitas LKPD dalam pembelajaran. Hasil pengembangan menunjukkan bahwa LKPD memiliki kualitas isi yang relevan dengan tujuan pembelajaran, disajikan dalam bentuk visual yang menarik, serta menggunakan bahasa yang komunikatif. Evaluasi pelaksanaan pembelajaran mengindikasikan bahwa produk mampu mendorong aktivitas belajar yang lebih kontekstual dan partisipatif. Dukungan dari respons guru dan peserta didik menguatkan bahwa LKPD dapat memfasilitasi keterampilan berpikir kritis peserta didik melalui eksperimen yang terarah dan bermakna. Kelayakan dan kepraktisan yang terpenuhi menjadikan LKPD ini sebagai salah satu alternatif media pembelajaran yang sesuai dengan karakteristik Kurikulum Merdeka dalam pendidikan dasar.

Kata Kunci: berpikir kritis; eksperimen; LKPD; sistem pernapasan

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INTRODUCTION

The development of critical thinking skills in elementary school students requires a learning approach that emphasizes active participation and direct experience. Experiments are one approach that provides students with space to build conceptual understanding through observation, testing, and independent drawing of conclusions (Wulandari *et al.*, 2025). This process fosters the ability to analyze, evaluate, and synthesize scientific information systematically, a key feature of critical thinking (Setiawan *et al.*, 2024). Student participation in experimental activities fosters reflective and rational thinking habits when engaging with scientific phenomena and increases interest in scientific content (Nurlaeli, 2022). Experiment-based science learning not only strengthens conceptual understanding but also serves as a means of instilling scientific methods as a deep, structured way of thinking (Ariani, 2020). Limitations in conducting experiments in elementary schools contribute to the low development of students' critical thinking skills.

Conceptual difficulties often arise when students learn complex science material that requires deep understanding. Epistemological barriers arise because students lack a comprehensive knowledge structure that enables an accurate understanding of scientific concepts. In contrast, didactic barriers stem from learning approaches that do not optimally support the development of this knowledge structure (Evitasari *et al.*, 2025). The lack of student involvement in experimental activities renders the learning process passive and meaningless, preventing the information obtained from forming long-term understanding (Payu, 2023). Learning that relies solely on text and verbal explanations tends to encourage students to memorize without conceptual understanding and even makes it difficult for them to relate the information to everyday reality. This tendency demonstrates weaknesses in students' analytical and critical thinking skills regarding scientific phenomena, which should be developed through experiential learning. This condition indicates the need for a learning approach that enables an active, contextual learning process through direct interaction with scientific objects of study.

The need for learning media that can stimulate higher-order thinking has led to the development of contextual, experiment-based worksheets oriented toward the scientific process (Haerani *et al.*, 2023). These worksheets not only serve as learning guides but also as instruments that integrate experimental procedures with structured critical-thinking activities. The existence of LKPD, designed to facilitate observation, measurement, data analysis, and conclusion drawing, provides a more authentic learning experience, thereby encouraging students to construct meaning independently (Suwastini *et al.*, 2022). The development of experiment-based LKPD is also consistent with the principles of the Merdeka Curriculum, which emphasizes learner-centered learning grounded in exploration and real-world problem solving (Anisa *et al.*, 2024). Learning activities grounded in experiments not only foster curiosity but also strengthen the ability to construct arguments and make decisions based on scientific evidence obtained through direct, hands-on procedures (Ramdani *et al.*, 2020). This urgency indicates that LKPD design must systematically incorporate critical thinking skills through structured, reflective experimental activities.

Critical thinking skills encompass a range of cognitive abilities that enable individuals to analyze information in depth, evaluate evidence, and construct arguments logically and rationally. The dimensions of critical thinking can be identified through the activities of analysis, evaluation, and creation, as reflected in the higher-order cognitive taxonomy (Dewi & Meilina, 2022). In science learning, this dimension is particularly important because it requires students not only to understand natural phenomena but also to interpret, connect, and draw conclusions from observations and empirical data (Endaryati *et al.*, 2021). Experiment-based learning is a strategic tool for developing these skills because it involves students in the scientific process through direct observation, measurement, analysis of results, and evaluation of the procedures and conclusions they make themselves. All activities in experiments require students to think reflectively, question the validity of data, and draw conclusions based on scientific rationality, all of which

are at the core of critical thinking. The synergy between critical thinking skills and scientific experimentation provides a strong foundation for science learning grounded in reasoning and empirical evidence.

The application of critical thinking skills in science learning becomes increasingly relevant when students encounter complex material, such as the human respiratory system. Understanding the function of organs, the mechanisms of inspiration and expiration, and the process of gas exchange requires sharp analytical skills and evidence-based information processing. These concepts cannot be fully understood through theoretical explanations alone; they require concrete experiences through experimental activities that enable students to make direct observations, record changes, and draw scientific conclusions (Octaviani *et al.*, 2024). Experiment-based learning provides students with opportunities to explore how the respiratory rate changes during physical activity and how lung capacity can be measured using simple tools. This process also trains students' ability to evaluate data, compare results, and assess the accuracy of the procedures performed (Beudels *et al.*, 2021). Experimental activities integrated with critical-thinking requirements make science learning more meaningful and contextual, and strengthen students' scientific reasoning in understanding the biological functions of the human body. This reinforcement of relevance creates a solid foundation for science learning designs that encourage active engagement and deep understanding among elementary school students.

The learning environment in class V of SDN 066050 Medan indicates significant obstacles to developing students' critical thinking skills, particularly in the subject of the human respiratory system. Learning activities remain dominated by lectures and conventional exercises, with little student involvement in exploratory scientific activities. The student worksheets used by teachers do not support active learning, as they consist of procedural activities that do not foster analytical or reflective skills. Students have difficulty explaining the relationship between physical activity intensity and breathing rate, and show limitations in presenting logical scientific reasons based on observation. These conditions reflect the lack of a culture of critical thinking in their learning routine. Simple experimental facilities are not yet readily available, so students do not gain learning experiences that enable them to connect theory to practice. The lack of contextual learning media also weakens students' ability to internalize concepts. These limitations highlight the need to develop experiential learning media to create meaningful learning experiences and to develop critical thinking skills continuously.

Suboptimal learning conditions for integrating experimental activities with the development of critical thinking necessitate targeted efforts through adaptive, needs-based learning designs. This study examines the effect of experiment-based worksheets on fifth-grade students' critical thinking skills in understanding the human respiratory system. The focus of this study is on testing the effectiveness of integrated experimental activities in worksheets as a means of active and reflective learning. This study examines the extent to which experiment-based worksheets can foster higher-order thinking through systematic scientific activities, enabling students to develop a deeper, more applicable conceptual understanding of the human respiratory system.

LITERATURE REVIEW

Ilmu Pengetahuan Alam (IPA)

Ilmu Pengetahuan Alam (IPA) is a branch of science that studies natural phenomena through a systematic approach based on observation, experimentation, and logical reasoning. The scientific process that underpins science produces knowledge that is objective, empirically tested, and reproducible. The study of science encompasses various concepts, principles, and laws of nature derived from careful observation and experimental testing. The essence of science lies not only in the results, in the form of a collection of concepts, but also in the processes of discovery and meaning formation through systematic scientific activities (Evtasari *et al.*, 2025). Effective science learning must introduce students to scientific thinking

from an early age, so that they become accustomed to using logic, evidence, and systematic reasoning to understand the phenomena around them. Strong science literacy will ultimately shape students' character to be resilient, critical, and adaptable to contemporary developments (Li & Guo, 2021).

The characteristics of elementary school students who are still in the concrete operational stage require a contextual, visual, and applied approach to science learning. The learning process will be more meaningful when students have the opportunity to observe, investigate, and draw conclusions from their direct experiences in experimental activities. Learning that focuses only on texts and abstract explanations tends to make it difficult for students to understand scientific concepts in depth. Exploratory activities, such as experiments and scientific inquiry, can foster the development of observation, analysis, and logical reasoning skills that are essential to the cognitive development of elementary school students (Purwati & Pradynyana, 2025). Such activities enable students to construct their own knowledge structures through direct interaction with the objects and phenomena being studied, making the learning process more active, participatory, and reflective.

Critical Thinking Skills

Critical thinking skills reflect a person's ability to analyze information logically, systematically, and evidence-based. This process includes activities such as identifying valid arguments, distinguishing facts from opinions, and drawing rational conclusions from available data (Milala *et al.*, 2024). This ability involves a reflective, independent mental process and requires the skills to analyze, evaluate, and synthesize information from various sources (Pigai & Yulianto, 2024). A learning environment rich in contextual problems, open interaction, and inquiry-based activities provides a strong space for systematically developing critical thinking skills. The application of learning strategies that encourage students to ask questions, engage in argumentation, and make evidence-based decisions will sustainably strengthen the development of higher-order thinking.

The integration of critical thinking skills into elementary school science education is essential for strengthening students' conceptual understanding of the scientific phenomena around them (Rohman *et al.*, 2023). Each stage of scientific learning, from formulating questions and designing experiments to analyzing observational data, is an opportunity to practice logical and reflective thinking. This process enables students not only to master the material but also to develop a scientific mindset through direct, experiential learning (Lestari *et al.*, 2023). Learning activities that emphasize exploration, testing, and evaluation encourage students to connect concepts to empirical evidence independently. Strengthening critical thinking through experiments is an effective bridge in building scientific skills and a strong learning character.

Experiment-Based Learning

Experimental learning is a scientific approach that places students as the primary actors in the process of discovering concepts through observation, variable manipulation, and drawing conclusions based on empirical data (Wardani & Djukri, 2020). This model requires students' active involvement in formulating hypotheses, designing procedures, conducting experiments, and evaluating results, thereby simultaneously training their logical, analytical, and critical thinking skills (Beudels *et al.*, 2021; Fadzilah *et al.*, 2020). The learning process is structured into systematic stages, beginning with problem formulation, hypothesis formulation, experimental design, activity implementation, and reflection on results (Çeliker, 2021; Rahmatika *et al.*, 2022). Experimental activities foster cognitive and emotional engagement among students and train them to apply scientific methods that are essential to science learning (Rohimat, 2022).

All of these views confirm that experimental learning can create an active, systematic, and meaningful learning process that aligns with the characteristics of competency-based science learning.

The effectiveness of this approach lies in its ability to create authentic learning experiences, thereby enhancing students' conceptual understanding, active participation, curiosity, and motivation to learn (Purwati & Pradynyana, 2025). Through concrete experiences, students develop scientific process skills such as systematic observation, data analysis, and evaluation of results (Deniş-Çeliker & Dere, 2022). However, conducting experiments requires careful planning, teacher guidance, and adequate facilities. Technical constraints, such as limited tools, time, or procedural carelessness, can affect the validity of results and the effectiveness of achieving overall learning objectives.

Lembar Kerja Peserta Didik (LKPD)

Lembar Kerja Peserta Didik (LKPD) serves as a learning tool that guides students in understanding teaching materials through systematic, targeted, and contextual activities. In addition to complementing teaching materials, LKPD helps direct learning interactions toward greater activity, reflection, and independence (Putra *et al.*, 2022). The preparation of LKPD must consider learning objectives, learner characteristics, and the integration of 21st-century skills, such as critical thinking and problem-solving (Ariyanti & Yunus, 2021). An effective LKPD structure involves curriculum analysis, goal formulation, content development, and evaluation preparation, with attention to competency achievement and learning indicators (Agustin *et al.*, 2024; Annisa *et al.*, 2023). Types of LKPD, such as guides, discoveries, applications, reinforcements, and practicums, provide teachers with flexibility to adjust their learning approaches.

The effectiveness of LKPD is influenced by the completeness of components such as learning objectives, work instructions, brief materials, activity sheets, and assessments that are compiled proportionally and structurally (Widodo *et al.*, 2023). The advantages of using LKPD include increased student engagement, encouragement of independent learning, and ease of learning management for teachers. However, challenges remain if LKPD is designed in a monotonous manner or is not aligned with students' cognitive development. A lack of variety in activities and minimal integration of supporting media can reduce the effectiveness of LKPD in achieving optimal learning outcomes.

METHODS

This study employs a quantitative, research-and-development approach to develop an experiment-based Student Worksheet (LKPD) that is feasible, practical, and effective for use in science learning. The development procedure refers to the ADDIE model, which has been modified into three stages, namely analysis, design, and development, taking into account efficiency and contextual field requirements. The research location was set at SDN 066050 Medan, which is administratively located in the city of Medan, North Sumatra. The research was conducted during the odd semester of the 2024/2025 academic year, from September to December 2024. The research subjects were fifth-grade students who participated in limited trials and field tests, and the research object was an experiment-based LKPD developed and tested to improve critical thinking skills in human respiratory system materials. The entire research process was designed to systematically assess the quality, feasibility, and effectiveness of the developed learning media using data obtained through expert validation, observation, and learning outcome tests.

This research follows the ADDIE model, which has been modified into five main steps: analysis, design, development, implementation, and evaluation. The analysis stage begins with a review of learning needs in the field, including curriculum analysis, learner characteristics, and the identification of problems in the fifth-grade curriculum on the human respiratory system. The results of this analysis form the basis for the

design stage, which focuses on structuring student worksheets, formulating learning objectives, and developing experimental scenarios appropriate to the cognitive development levels of elementary school learners. The development process includes creating LKPD prototypes and validating them with subject matter experts, media experts, and classroom teachers to assess the feasibility of the content, language, and appearance. After undergoing revisions based on the validators' input, the LKPD is tested in the implementation stage through limited testing and field testing with fifth-grade students as active participants. Feedback from the implementation stage is used in the evaluation stage to assess the practicality and effectiveness of the LKPD, including through observation of student activities and analysis of critical-thinking test results. All of these stages are designed to ensure that the resulting product is not only valid and practical but also capable of tangibly improving the quality of learning.

Data collection in this study employed three primary techniques: expert validation, questionnaire distribution, and test implementation. Validation was conducted to assess the feasibility of the LKPD in terms of content, language, and visual appearance using assessment sheets completed by subject matter experts, media experts, and classroom teachers. The questionnaire was used to assess students' and teachers' perceptions of the practicality of the LKPD. In contrast, the test, in the form of essay questions, was used to evaluate students' critical thinking skills before and after using the media. All instruments were developed in accordance with critical-thinking indicators across the cognitive domains of analysis, evaluation, and creation, and have undergone content validation to ensure that the questions are accurate and relevant to the research objectives. The data were analyzed descriptively and quantitatively, using percentage-based measures and the N-Gain Score to assess improvements in learning outcomes and the effectiveness of LKPD. This technique was used to objectively assess the extent to which the developed learning media met the criteria of feasibility, practicality, and effectiveness, based on field data collected during implementation.

RESULTS AND DISCUSSION

Analysis Stage

The analysis stage of this study focused on reviewing the curriculum and student characteristics to inform the development of relevant learning media. Observations of the implementation of the Merdeka Curriculum indicated that the learning approach used in fifth grade provided students with opportunities to construct knowledge through contextual and meaningful activities. The material on the human respiratory system in science lessons requires students' active involvement in observation, experimentation, and scientific communication. This principle aligns with the essence of learning, which focuses on strengthening higher-order thinking skills, particularly critical thinking. However, the actual classroom conditions indicate that learning activities are not yet fully supported by routine experimental practices. Teachers still tend to rely on conventional approaches such as lectures and assignments, limiting students' opportunities to explore concepts through scientific activities. This gap underscores the importance of learning media that support the full and contextual implementation of the Merdeka Curriculum.

The use of experiential LKPD is considered strategic in addressing these needs because it can encourage active student involvement in observation, exploration, and reflection. LKPD designs that are integrated with simple experiments can create learning experiences that stimulate deeper cognitive activity in students. This opportunity also supports the strengthening of the Pancasila Student Profile in the dimensions of critical thinking and independence, which are the direction of national education transformation. The analysis of student characteristics indicates that the majority of fifth-grade students at SDN 066050 Medan tend to learn through concrete activities. Students' interest increases when learning involves practice or demonstrations, whereas one-way methods lead to declines in attention and motivation. When given questions that require analysis or the comparison of concepts, students have

difficulty constructing logical answers. This condition is exacerbated by the limitations of conventional LKPD, which are not yet able to stimulate critical thinking skills.

Field findings show that students need media that not only convey information but also guide the thinking process and encourage exploration of scientific phenomena. Teachers stated that no teaching tool is available that systematically links experimental activities to critical thinking skills. Based on this, the development of experiment-based worksheets has become an urgent need to address the problem of theoretical learning. The learning objectives should be directed not only toward mastering the respiratory system but also toward students' ability to interpret data, assess cause-and-effect relationships, and conclude direct experience. The worksheet design must stimulate thinking through scientific activities tailored to the characteristics of elementary school students. Through this approach, science learning can become more meaningful and enjoyable, and improve overall learning outcomes.

Design Stage

The design stage began with the determination of the main topic, namely, the human respiratory system, for fifth-grade elementary school students. This topic was chosen due to its urgency in the science curriculum and its potential to be delivered through an experimental approach. The initial design focused on developing detailed learning outcomes, indicators, and activity objectives. The learning objectives were formulated to enable students to describe the structure, function, and mechanisms of operation of the respiratory organs, thereby informing the selection of relevant content and experimental activities. The experimental activities were designed to suit the characteristics of elementary school students and could be carried out using simple tools. One of the main experiments involved making a model of the respiratory system using bottles, straws, and balloons. This activity allows students to observe the movement of an artificial diaphragm during inspiration and expiration and to understand the relationship between changes in chest cavity volume and airflow. The participatory nature of this activity is designed to increase student engagement and understanding of the concept of breathing in concrete terms.

The LKPD material is compiled systematically, in stages, in accordance with the experimental workflow. Each section of the material is explained using simple language and accompanied by visual illustrations to reinforce students' understanding of the functions of each respiratory organ. The material is also summarized to facilitate students' recall of the main concepts. All information is presented in a way that supports the experiment and makes abstract concepts more tangible for students. The LKPD structure includes space for discussion and reflection, encouraging students to analyze their observations and relate them to the scientific concepts under study. The questions in this section are designed to stimulate critical thinking skills, such as inferring relationships between variables from experimental data. Observation tables are designed to help students systematically record and organize information obtained during experiments. These tables reinforce the structure of activities and guide students in compiling relevant data based on direct observation. These elements are designed to support logical and analytical thinking processes within critical thinking skills training.

The LKPD design also considers the balance of roles between teachers and students. Teachers are provided with technical instructions for conducting experiments and strategies for creating a classroom environment that supports scientific activities. Meanwhile, students receive clear instructions to carry out activities both individually and in groups. This design ensures that the entire learning process is structured, participatory, and aligned with the learning objectives. Initial implementation indicates that students can assemble respiratory models and conduct experiments in accordance with the procedure. During implementation, students show high interest and active involvement in observing changes in balloon shape as a representation of air flow. They can also explain the relationship between these physical processes

and the respiratory system. Observation results indicate that most students meet the success indicators set out in the activity plan.

The series of activities during the design stage demonstrated that experiment-based LKPDs can accommodate students' needs for understanding scientific concepts in a fun and meaningful way. This medium not only conveys theory in an informative manner but also provides direct experiences that shape conceptual understanding and critical thinking skills. The initial design of the LKPD is shown in **Figure 1** as a concrete manifestation of the components developed systematically and in context.



Figure 1. Preliminary design of experiment-based LKPD
Source: Research 2025

Development Stage

The development stage began with product validation by subject matter, media, and language experts. The designed LKPD was submitted to validators for feasibility assessment using a questionnaire. The assessment focused on the suitability of the subject matter, language presentation, and the relevance of the experimental activities to the learning objectives. The validation results from subject matter experts are presented in **Table 1**, which shows a score of 54 out of 64, corresponding to a suitability percentage of 84%. This score indicates that the LKPD is deemed suitable for use with some notes for improvement.

Table 1. Expert Assessment Results for Products

Assessment Aspects	Assessment Indicators	Assessment
Content suitability	Quality of learning materials	8
	Learning delivery system	20
Presentation	Quality of learning strategies	18
Language	Quality of learning materials	6
Image selection	LKPD display	2
Total score		54

Source: Research 2025

Subject-matter experts also validated the critical thinking skills test used in the study. The assessment covered aspects such as the suitability of the questions to the indicators, the clarity of language, and their relevance to the learning outcomes. **Table 2** presents validation results with a score of 46 and an 88% percentage, indicating that the test instrument is of high quality and ready for empirical testing. The empirical testing procedure was conducted in other public schools with characteristics similar to those of the target school to ensure the questions' measurability in a real learning context. The results showed that 20 questions were empirically valid and capable of measuring students' critical thinking competencies.

Table 2. Expert Assessment Results for Instruments

Assessment Aspects	Assessment Indicators	Assessment
Question instructions	Question instructions are written clearly, concisely, and in a way that is easy for students to understand.	4
	STEM questions present clear problems and are concise.	3
	STEM questions do not provide clues that directly point to one of the answer choices.	3
Material	The material is relevant and measures the achievement of predetermined learning objectives.	4
	The questions cover material that has been taught.	4
	The difficulty of the questions is appropriate for the students' cognitive level.	3
	The material is relevant to the students' life context.	4
Question construction	The questions or statements in STEM are easy to understand.	4
	The answer keys are clear and leave no room for doubt.	3
	The incorrect answer choices attract the attention of students who do not understand the material well.	2
Language	Questions use standard and correct grammar in accordance with Indonesian language rules.	4
	The choice of words used is appropriate so that they are easy to understand.	4
	The questions are written in simple, non-convoluted sentences.	4
Total Score		46

Source: Research 2025

The reliability of the questions was also assessed to evaluate measurement consistency, yielding a reliability coefficient of 0.75, which is in the high range. The difficulty-level analysis resulted in 3 difficult, 3 easy, and 14 medium questions, indicating an even distribution. The assessment of discriminative power showed that 15 questions were classified as very good and 5 as good, indicating that they effectively distinguished between the achievements of high- and low-ability students. All validation results indicated that the test instrument was suitable for evaluating student learning outcomes in the implementation of experiment-based LKPD.

The validation process for linguistic aspects focused on content suitability, delivery strategy, language clarity, and the selection of images that support the LKPD's appearance. The assessment results are presented in Table 3 and indicate a score of 47 out of 56 (83.9%). This score indicates that the LKPD is

suitable for field testing in learning, although there are still some notes for revision regarding language use and visual appearance.

Table 3. Results of Language Expert Assessment

Assessment Aspects	Assessment Indicators	Score
Language usage aspects	Accuracy of sentence structure	3
	Effectiveness of sentences	3
	Clarity of language in the material	3
	Clarity of sentences	3
	Appeal of language style	3
	Use of proper and correct Indonesian language rules	3
Language accuracy	Clarity of letters	4
	Symbols used	3
	Clarity of commands/instructions	4
	The language used is simple, straightforward, and easy to understand	4
	Uses improved spelling (EYD)	3
Aspects of suitability for student development	Language is adapted to the developmental stage of students	3
	Language can stimulate students' imagination	4
	Language is easy for students to understand	4
Total		47

Source: Research 2025

Expert design validators assessed the visual design of the LKPD, including its appearance and readability. The validation process focused on the size, layout, typography, illustrations, and visual content of the LKPD. **Table 4** presents the assessment results, with a total score of 95 out of 108 and a percentage of 87.9%. This score indicates that the product meets the criteria for high feasibility and does not require revision. This validation confirms that the LKPD design meets aesthetic and functional standards for science learning in elementary schools.

Table 4. Media Expert Assessment Results

Assessment Aspects	Assessment indicator items	Assessment
LKPD size	Compliance of LKPD size with ISO standards	4
	Compliance of size with LKPD content	3
Layout	Good center of attention display on titles and illustrations	4
	Proportional comparison of layout element sizes	4
Typography	The title of the LKPD should be the focal point	4
	Do not use more than two fonts	4
	Do not use excessive decorative fonts	4
	The font should be appropriate for the content of the LKPD	3
Illustration	Illustrations can describe the contents of LKPD	4
	Character of objects	4

Assessment Aspects	Assessment indicator items	Assessment
	Proportionality of objects in reality	4
	Illustration sources	4
Layout of content	Consistent placement of elements based on the LKPD content pattern	3
	Clear spacing between paragraphs and no widows or orphans	3
	Consistent placement of titles	4
	Print area and margins proportional to the size of the LKPD	3
	The distance between text and illustrations is proportional	3
	LKPD title	3
	The use of font variations (bold, italic, all capital, small capital) is not excessive	3
	Font size and type are appropriate for the level of education	3
	Text layout width	3
	Spacing between lines of text is normal	3
	There are no white lines in the text layout	3
Illustration of LKPD	Content clearly depicts the material	3
	Proportional shape represents the character of the object	4
	The overall illustration is harmonious and creative	4
	Lines and rasters are firm and clear	4
Total		95

Source: Research 2025

Implementation Stage

The implementation stage was conducted after the experimental-based LKPD product was deemed feasible based on validation results from subject matter, language, and design experts. At this stage, a practicality test was conducted to measure the ease of use of the LKPD by teachers and students. The results of the teachers' assessment of the practicality of the LKPD are shown in **Table 5**, with a percentage of 95%, indicating that it is very practical. These findings indicate that the LKPD can be used effectively to teach fifth-grade students about the human respiratory system without significant technical obstacles.

Table 5. Practical Test Results by Teachers

Assessment Aspects	Assessment indicator items	Assessment
Usable	Accuracy of indicators for use in teaching the human respiratory system.	4
	Suitability of material for use in fifth-grade elementary school classes	4
	Accuracy of student worksheets in responding to user actions	3
Easy to use	Completeness of material in LKPD	4
	Ease of use of LKPD	3
Appealing	Appropriateness of font types in LKPD	4
	Image display in LKPD	4

Assessment Aspects	Assessment indicator items	Assesment
	Color combination in LKPD books	4
Efficiency	Clarity of usage instructions	4
	Appropriateness of LKPD usage in relation to learning time allocation	4
Total		38

Source: Research 2025

Student involvement in practical testing was achieved by distributing questionnaires after the use of the LKPD in direct learning. Five selected students gave practicality scores in the range of 80-100, which is classified as very practical, as shown in **Table 6**. Furthermore, small-group trials were conducted to assess students' initial responses to the product before its widespread implementation. Five students from outside the research class were selected purposively based on variations in academic ability. The observation results showed that all students found the LKPD easy to understand and interesting, and no obstacles were encountered in its use; therefore, the product immediately proceeded to the classical trial stage.

Table 6. Student Practicality Assessment Score

Students	Score
Student 1	83
Student 2	85
Student 3	98
Student 4	95
Student 5	98

Source: Research 2025

The field trial involved 28 fifth-grade students with pretest and posttest procedures using 20 validated multiple-choice questions. The comparison results showed an increase in scores from an average of 53.04 to 85.18, as shown in **Figure 1**. This increase indicates the effectiveness of LKPD in helping students understand the respiratory system.

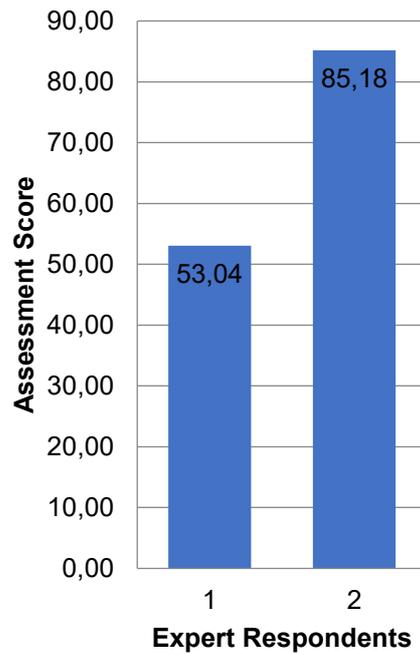


Figure 1. Comparison of Pretest and Posttest Results
 Source: Research 2025

A further analysis of student learning completeness was conducted to assess the extent to which experiment-based LKPDs effectively supported the achievement of critical thinking indicators. This evaluation compared students' actual learning achievements with the established minimum completion criteria, thereby providing an objective assessment of the effectiveness of the developed tools. The mastery data are presented in detail in Table 7 and serve as the basis for assessing the quality of LKPD implementation, with respect to content, the integration of experimental activities, and relevance to the learning objectives of the Merdeka Curriculum.

Table 7. Completion of Student Learning Outcomes

Score	Pre-test	Post-test
Highest	80	95
Lowest	10	75
Average	53.04	85.18

Source: Research 2025

Evaluation Stage

The evaluation stage concludes the research process for developing an experiment-based LKPD on the human respiratory system. The evaluation was conducted using practicality and effectiveness test data collected from teachers and students following the use of LKPD in learning. The practicality assessment from teachers was 95%, and from students it ranged from 80 to 100, both indicating a very practical category. The effectiveness test results showed a significant increase in students' pretest-to-posttest scores, with the average score rising from 53.04 to 85.18. Based on this analysis, the developed LKPD was deemed effective and highly practical for learning, requiring no further revisions. This decision is

reinforced by observations during implementation, which documented active student involvement and positive responses to the LKPD's appearance, content, and ease of use.

Discussion

Expert validation indicates that the experiment-based Student Worksheet (LKPD) on the human respiratory system for fifth-grade elementary school students substantially meets content feasibility standards, based on basic competencies, learning objectives, and students' cognitive development characteristics. The percentages of validation results from subject matter experts, namely 84%, 88%, and 83.9%, fell within the feasible range. The aspects assessed include clarity of presentation, conceptual accuracy, relevance to learning objectives, and suitability with the scientific approach in the Merdeka Curriculum. Minor improvements, such as editorial adjustments, conceptual reinforcement, and enhanced visual illustrations, were also implemented to enhance quality. The test instruments have also been validated by subject-matter experts based on the relevance of the questions to critical-thinking indicators, student understanding, and appropriate linguistic structure and construction (Dewi & Meilina, 2022). The validation score from media/design experts was 87.9% and fell within the very feasible category, with assessment indicators including aesthetics, display balance, and overall LKPD navigation (Setiawan *et al.*, 2024). All validation results indicate that the developed product has the potential to promote effective learning through experimental activities and a contextual approach based on students' direct experiences (Putri & Meilana, 2023). This LKPD is deemed suitable for implementation in field trials to assess its effectiveness in developing critical thinking skills among elementary school students.

The practicality assessment of the experiment-based LKPD involved teachers and fifth-grade students at SD Negeri 066050. Teachers awarded a score of 95 percent of the maximum total score, indicating that the LKPD is highly practical because it is easy to use, meets students' needs, and supports effective IPAS learning. Five fifth-grade students also assessed the LKPD used, and all gave scores in the range of 80 to 100, indicating that it was considered very practical by direct users. These findings reinforce research indicating that attractively designed LKPDs that use communicative language and include contextual activities can increase student engagement in the learning process (Milala *et al.*, 2024). These results reinforce that the product is not only suitable for use but also has significant potential to support active and meaningful learning about the human respiratory system. This finding provides a basis for assessing the product's effectiveness in the final stage of development evaluation.

The implementation of experiment-based LKPD in IPAS learning on the human respiratory system had a positive impact on improving the learning outcomes of fifth-grade students at SD Negeri 066050. The average posttest score increased from 53.04 to 85.18, with a higher and more uniform score distribution than the pretest. All students achieved classical mastery, reflecting the effectiveness of LKPD in helping students understand the material more optimally. The active learning process through experimental activities enabled students to develop their own understanding through real-world experiences. This improvement can also be explained by the four stages of experiential learning: concrete experience, reflection, conceptualization, and application (Rohimat, 2022). Structured learning activities encourage analysis, evaluation, and creation as components of critical thinking, in accordance with Bloom's Revised Taxonomy. The effectiveness of LKPD is also reflected in the evaluation design, which employs pre- and post-tests, strong indicators of learning tool effectiveness (Fadzilah *et al.*, 2020). This finding is reinforced by a study reporting that experiential LKPD can improve learning outcomes and critical thinking through its contextual and applied approach (Wulandari *et al.*, 2025). Therefore, the use of experiment-based LKPD is not only effective in improving academic achievement but also supports the development of critical thinking skills, an essential competency in IPAS learning within the Merdeka Curriculum.

CONCLUSION

This study concluded that the development of experiment-based Student Worksheets (LKPD) on the human respiratory system was valid, practical, and effective for use in science and mathematics instruction in fifth-grade elementary schools. The product's validity was established through expert assessments of the material, media, and language, which indicated that the LKPD was suitable for use, requiring only minor revisions. Practicality was rated very high based on teachers' and students' responses, which indicated ease of use and the suitability of the LKPD's content and appearance to students' characteristics. The effectiveness of the LKPD was reflected in significant improvements in student learning outcomes after implementation, as well as in the attainment of classical mastery, which demonstrated the LKPD's contribution to the development of critical thinking skills. Based on these findings, it is recommended that the development of similar learning tools be applied more widely, with varied material coverage, to support the achievement of 21st-century competencies and to serve as a reference for teachers and researchers in designing contextual learning centered on student activities.

AUTHOR'S NOTE

The author declares that there is no conflict of interest related to the publication of this article. The author confirms that the data and content of the article are free from plagiarism.

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