

DEVELOPMENT OF AN INQUIRY-BASED INTERACTIVE STUDENT WORKSHEET ON THE RESPIRATORY SYSTEM AT SMAN 1 KAWANGKOAN BARAT

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ABSTRACT

The learning process of the respiratory system at SMA Negeri 1 Kawangkoan Barat requires interactive learning resources that can encourage students' active involvement and support their learning motivation. This study aimed to develop an inquiry-based interactive student worksheet on the respiratory system and to determine its validity, practicality, and effectiveness in supporting students' learning motivation. The study employed a Research and Development (R&D) approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The participants in the limited trial were eight Grade XI students. Data were collected through material and media expert validation sheets, student response questionnaires, learning motivation questionnaires, observations, and interviews. The results showed that the worksheet obtained a score of 84.52% from the material expert and 97.6% from the media expert, indicating a very high level of validity. The student response score was 84.64%, indicating that the worksheet was highly practical. Students' average learning motivation increased from 22.5 in the pretest to 37.1 in the posttest, with an N-Gain score of 0.83, categorized as high. These findings indicate that the developed inquiry-based interactive student worksheet is valid, practical, and effective in supporting students' learning motivation in studying the respiratory system.

Keywords: inquiry-based learning; liveworksheets; respiratory system; learning motivation

INTRODUCTION

Education plays an important role in developing students' knowledge, skills, and potential. In the learning process, students are expected to be actively involved rather than only receive information. Therefore, learning requires appropriate approaches and learning resources that can encourage students' active participation and motivation.

However, learning practices in many educational settings remain relatively monotonous and lack innovation. The extensive use of one-way lecturing without adequate variation in learning media may cause students to become bored and lose interest in learning. As a result, their active participation can be reduced, which may

ultimately affect the quality of learning outcomes (Bappenas, 2025). Low levels of student motivation may also be associated with limited interaction between teachers and students, as well as the inadequate use of technology and learning media that can stimulate students' interest, creativity, and engagement in the learning process (Adriani, 2020; Mustikaati et al., 2025).

A similar situation was identified at SMA Negeri 1 Kawangkoan Barat. Based on a brief interview conducted with eight Grade XI students, all respondents reported that they had never used digital worksheets, or student worksheets (LKPD), during their learning activities. The learning process was still mainly conducted through

lectures, note-taking, and written assignments. Furthermore, seven out of the eight students stated that they became bored easily, particularly when learning abstract topics such as the respiratory system in Biology. These findings suggest that students' low learning motivation may be related to the limited use of innovative and interactive learning media in the school. Therefore, the integration of interactive learning resources is needed to create a more engaging learning experience and encourage students to participate more actively in the learning process.

Interactive student worksheets (LKPD) can be used as an alternative learning resource because they combine learning materials with multimedia and interactive activities. Previous research by Jannah et al. (2024) developed an E-LKPD based on Problem-Based Learning using Liveworksheets and reported good levels of validity, practicality, and effectiveness. Other studies have also developed electronic worksheets using approaches such as discovery learning and STEM-based learning. These findings indicate the potential of interactive digital worksheets to support active learning, although previous studies differ in learning approach, subject matter, educational level, and learning outcomes.

Therefore, this study aimed to develop an inquiry-based interactive student worksheet on the respiratory system at SMA Negeri 1 Kawangkoan Barat and to determine its validity, practicality, and effectiveness in supporting students' learning motivation. Interactive student worksheets combine learning materials with digital multimedia and interactive activities, such as images, videos, and exercises, to provide students with a more varied learning experience (Mayasari,

2023). One platform that can be used to develop interactive worksheets is Liveworksheets, which allows conventional worksheets to be transformed into digital learning activities with interactive questions and automatic feedback. These features make Liveworksheets relevant for supporting learning activities on the respiratory system, which involves abstract concepts and processes that are difficult to observe directly.

Inquiry-based learning emphasizes students' active involvement in constructing knowledge through activities such as observation, question formulation, investigation, data analysis, and conclusion drawing. This approach is relevant to the respiratory system because the topic involves abstract concepts and physiological processes, including respiratory mechanisms and gas exchange. Through structured inquiry activities, students can explore these concepts actively and develop their understanding. Previous studies have also supported the use of interactive electronic worksheets in science learning. Utari et al. (2025) developed an interactive e-LKPD based on Discovery Learning and reported that the product was valid and effective in supporting students' scientific communication skills. Sa'diyah et al. (2024) also demonstrated the potential of interactive electronic learning media to support students' learning outcomes and competencies. However, these studies differ from the present study in terms of learning approach, learning topic, and learning outcomes examined.

The novelty of this study lies in the integration of an inquiry-based learning sequence with an interactive digital worksheet for respiratory system learning at

the senior high school level. The developed LKPD guides students through problem orientation, problem formulation, hypothesis formulation, investigation, data analysis, and conclusion drawing. These activities are supported by interactive features such as instructional videos, interactive exercises, automatic feedback, self-reflection, and an educational word-search activity. Thus, the product is designed not only to provide digital learning materials but also to involve students actively in the learning process and provide opportunities for immediate feedback and reflection. In addition, this study examines the product in relation to

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The model was selected because its systematic stages support the development, validation, implementation, and evaluation of the inquiry-based interactive LKPD. The second stage was the design stage, in which the researcher developed the sequence of learning activities, the LKPD interface, interactive activities designed to support students' learning motivation, and the integration of supporting media. At this stage, the research instruments were also prepared, including validation sheets for material and media experts, a student response questionnaire, and a learning motivation questionnaire administered before and after the use of the interactive LKPD. In designing the product, Liveworksheets was used as the primary platform for developing the interactive LKPD because it enables conventional worksheets to be transformed

students' learning motivation, which distinguishes it from previous studies that primarily addressed scientific literacy, communication skills, or other learning outcomes

Based on the identified needs and research gap, this study was conducted to develop an inquiry-based interactive Student Worksheet (LKPD) on the respiratory system for Grade XI students at SMA Negeri 1 Kawangkoan Barat. The study also evaluated the developed product in terms of validity, practicality, and effectiveness in supporting students' learning motivation.

into engaging digital formats equipped with interactive activities, such as matching exercises, fill-in-the-blank tasks, and multiple-choice questions. Canva was also used as a supporting design tool to create the visual appearance of the LKPD, including its layout, color selection, and illustrations, so that the product would be more attractive and communicative.

The third stage was the development stage, which involved realizing the design prepared in the previous stage. The initial interactive LKPD product was validated by material and media experts. The material expert assessed the suitability and accuracy of the content, language, and learning objectives, while the media expert assessed the visual design, readability, usability, and interactivity of the product. The suggestions and feedback provided by the experts were used as the basis for revising the product before its implementation.

The fourth stage was the implementation stage, which involved a limited trial of the validated and revised product with eight Grade XI Science

students at the school. The activities at this stage included administering the learning motivation questionnaire before the use of the LKPD, implementing the inquiry-based interactive LKPD in biology learning, administering the learning motivation questionnaire after its use, distributing the student response questionnaire, and collecting teacher feedback regarding the ease of use, attractiveness, and usefulness of the interactive LKPD.

The final stage was the evaluation stage, which was conducted to assess the overall quality of the developed product. The evaluation involved analyzing the validation results based on expert assessments, analyzing the practicality of the product based on students' responses, and analyzing its effectiveness by comparing students' learning motivation scores before and after the use of the interactive LKPD. The results of these analyses were used to determine the validity, practicality, and effectiveness of the developed inquiry-based interactive LKPD in improving students' learning motivation.

The research was carried out in June 2026 during the second semester of the 2025/2026 academic year. The research activities were carried out at two different locations according to the requirements of each research stage. The product trial involving students was conducted at SMA Negeri 1 Kawangkoan Barat, while product validation by the media and material experts was conducted at the respective experts' university workplace.

The subjects of this study were Grade XI Science students at SMA Negeri 1 Kawangkoan Barat. A total of eight students were selected to participate in the limited product trial. Participants were selected using purposive sampling, a

technique in which the researcher determines the participants according to specific criteria that correspond to the purpose of the study. The selected students were from the Science program and had studied the respiratory system topic, making them appropriate participants for the product trial and consistent with the needs and objectives of the study.

The product developed in this study was an inquiry-based interactive Student Worksheet (LKPD) on the respiratory system topic. The product development utilized two main applications, namely Liveworksheets and Canva. Liveworksheets was used as the primary platform to transform conventional worksheets into interactive digital formats, featuring activities such as matching exercises, fill-in-the-blank tasks, and multiple-choice exercises equipped with automatic feedback. These features were designed to actively engage students in the learning process while providing immediate feedback, which was expected to enhance their learning motivation. Meanwhile, Canva was used as a supporting design tool to create the visual appearance of the LKPD, including the layout, color selection, and addition of illustrations, making the product more attractive and communicative for students. Research instruments are tools used by researchers to obtain the data required throughout the research process. In the development of the interactive LKPD, several instruments were prepared and used to measure the validity, practicality, and effectiveness of the developed product.

The first instrument was an expert validation sheet, which was used to assess the feasibility of the interactive LKPD before its implementation in the learning process. The validation involved two

groups of validators, namely a material expert and a media expert. The material expert was a lecturer with expertise in the respiratory system, while the media expert was a lecturer with expertise in educational technology or instructional media. The validation aimed to assess the suitability of the content, language, presentation, visual appearance, attractiveness, readability, and design of the interactive LKPD. The validation results were used as a basis for revising and improving the product so that it met the required feasibility standards before being tested with students.

The second instrument was a student response questionnaire, which was used to determine the practicality of the developed interactive LKPD. The questionnaire was administered to students after they had used the interactive LKPD in the learning process to obtain information about their responses to the appearance, ease of use, clarity of the material, attractiveness, and usefulness of the interactive LKPD. The student response questionnaire was adapted from Pratiwi I Gusti Ayu Widia (2025) without modification. The instrument consisted of five indicators and ten items, namely readability and clarity of the LKPD language (2 items), LKPD appearance and design (4 items), quality and suitability of the material (1 item), students' learning motivation and interest (2 items), and clarity of the LKPD usage instructions (1 item).

The third instrument was a student learning motivation questionnaire, which was used to determine the effectiveness of the interactive LKPD in improving students' learning motivation. The questionnaire was administered twice, namely before the use of the interactive LKPD (pretest) and after its use (posttest), to identify changes in students' learning motivation following the

use of the developed product. The indicators of learning motivation in this study included interest, attention, enthusiasm, and student participation during the learning process. The instrument was adapted from Suci Wijati (2019) and adjusted to the needs of this study. The instrument consisted of ten indicators: attention during learning activities, active participation in asking questions when experiencing learning difficulties, initiative in seeking additional information, interest and enjoyment in participating in learning activities, ability to relate the material to everyday life, confidence in expressing opinions, enthusiasm for achieving good learning outcomes, enjoyment in completing assignments or exercises, persistence in completing the exercises provided, and satisfaction in understanding the learning material.

The fourth instrument was a teacher interview guide, which was used to obtain information regarding the teacher's responses after students had used the interactive LKPD during the learning process. The interview aimed to obtain the teacher's views on the content feasibility, ease of use, suitability of the LKPD with the learning material, student engagement during the learning process, and the influence of the interactive LKPD on students' learning motivation. The interview results were used as supporting information for evaluating and improving the developed interactive LKPD.

The fifth instrument was an observation sheet for the implementation of the interactive LKPD, which was used to determine the extent to which the inquiry-based interactive LKPD was implemented during the learning process. The observed aspects included the implementation of the learning steps by the researcher and

students' involvement in using the LKPD. The observation sheet was adapted from the learning implementation observation instrument used by Amanullah (2017) and adjusted to the characteristics of the inquiry-based interactive LKPD developed in this study. The observation data were used as supporting data to strengthen the assessment of the practicality of the developed product.

The analysis of the research data employed both quantitative and qualitative methods. Quantitative analysis was applied to the assessment results provided by the material and media experts to determine the feasibility level of the interactive LKPD developed in this study. The expert assessment was collected through validation instruments based on a four-level Likert scale, with scores ranging from 1 to 4.

The percentage of the assessment results was calculated using the following formula:

$$P = (\Sigma X / (N \times X_{\max})) \times 100\%$$

In this formula, *P* indicates the percentage of the assessment obtained, ΣX refers to the accumulated score given by the validator, *N* denotes the total number of assessment items, and $X_{\max}$ refers to the highest possible score assigned to each item. The resulting percentage was subsequently classified according to four levels of product feasibility. A percentage between 0% and 40% was classified as not feasible, 41%–60% as less feasible, 61%–80% as feasible, and 81%–100% as highly feasible. The classification follows the feasibility criteria proposed by Handayani (2018). Therefore, the interactive LKPD was regarded as suitable for implementation when the assessment result fell within the feasible or highly feasible category.

In addition to the product feasibility criteria, the results of the student learning motivation questionnaire were also analyzed using percentages and interpreted according to the learning motivation categories adapted from Sugiyono (2019). The categories were as follows: 0%–40% was categorized as poor, 41%–60% as fair, 61%–80% as good, and 81%–100% as very good. The effectiveness of the interactive LKPD in this study was assessed based on the improvement in students' learning motivation rather than cognitive learning outcomes. To further support the analysis of the improvement in students' learning motivation, the N-Gain analysis was also conducted to determine the level of improvement before and after the use of the interactive LKPD. The N-Gain was calculated using the following formula:
$$N\text{-Gain} = (\text{Posttest} - \text{Pretest}) / (\text{Maximum Score} - \text{Pretest})$$

The interpretation criteria were based on Hake (1999), with an N-Gain value greater than 0.70 categorized as high, a value of 0.30–0.69 as medium, and a value below 0.30 as low.

Qualitative data in this study consisted of descriptions, comments, suggestions, criticisms, and responses concerning the developed interactive LKPD. These data were used as a basis for evaluating and improving the product to ensure that it was consistent with learning needs. Qualitative data were obtained from expert validation in the form of comments, criticisms, and suggestions regarding the suitability of the material, language use, media appearance, design, readability, and completeness of the LKPD. The information obtained was used as a basis for revising and improving the product before its implementation with students.

In addition, qualitative data were obtained through interviews with the Biology teacher after the students had used the interactive LKPD on the respiratory system topic. The aspects examined included the suitability of the material with the learning objectives, ease of use of the interactive LKPD, student engagement during the learning process, students' interest in the LKPD, and the influence of

using the interactive LKPD on students' learning motivation. The qualitative data were analyzed descriptively by collecting, organizing, and describing the information obtained from the validators and Biology teacher. The results were then used as supporting information for evaluating and improving the developed interactive LKPD.

RESULT AND DISCUSSION

This study produced an interactive inquiry-based Student Worksheet (LKPD) on the respiratory system for Grade XI senior high school students, developed using the ADDIE model. The development of the LKPD utilized Liveworksheets as the main platform for transforming a conventional worksheet into an interactive digital format, while Canva was used to support the visual design of the product. The resulting product was systematically organized and consisted of a cover page, student identity and user instructions, learning outcomes, learning achievement indicators, learning objectives, and concise learning materials complemented by instructional videos. It also included a series of inquiry-based activities, beginning with problem orientation, problem formulation, hypothesis formulation, investigation, data analysis, and conclusion drawing. The product was also equipped with a self-reflection section, a learning evaluation consisting of multiple-choice questions, and an educational word-search game at the end of the worksheet, which was designed to enhance students' learning interest.

The material validation was conducted by a validator with expertise in Biology education to assess the suitability

of the content of the developed interactive Student Worksheet (LKPD).

Table 1. Results of Material Expert Validation

No	Assessment aspect	percentage	category
1	Suitability of the material with the learning objective	75%	Feasible
2	Material presentation	90%	Highly feasible
3	Language	75%	Feasible
4	Suitability with learning principles and the curriculum	100%	Highly feasi
Average		84.52%	Highly feasible

The validation results showed that the interactive LKPD obtained an overall feasibility percentage of *84.52%, which was categorized as highly feasible. Several suggestions for improvement provided by the validator, such as adding illustrations to the discussion of inspiration and expiration and providing additional labels to the illustration of the gas exchange process, were addressed by the researcher through product revisions. These revisions were made to ensure that the material presented was clearer and easier for students to understand.

The media validation was conducted by a validator with expertise in learning media and educational technology to assess the visual quality, design, readability, navigation, interactivity, and ease of use of the developed interactive LKPD.

Table 2. Result of Media Expert Validation

No	Assessment Aspect	percentage	category
1	Visual display	91.7%	Highly feasible
2	Quality of interactive media	100%	Highly feasible
3	Alignment with material	100%	Highly feasible
4	Usability aspect	100%	Highly feasible
Average		97.6%	Highly feasible

The validation results show at total percentage of 97.6%, categorized as Highly feasible. Several suggestions from the validator including replacing illustrative images with authentic photographs, correcting spelling errors, moving the instructions for use to the beginning of the LKPD, presenting learning objectives of in point form, and adding a link to the instructional video were followed up through product revision.

The practicality of the interactive LKPD was measured through a student response questionnaire administered after the lesson using the LKPD.

Table 3. Results of the Student Response Questionnaire

No	Assesment aspect	item numers	percentage
1	readability	1,2,10	88.54%
2	LKPD display/desig n	3,6,7,8	78.12%
3	Alignment of material	4	87.50%

4	Motivation and interest in learning	5,9	84.38%
Average			84.64%

The result is supported by the observation of implementation fidelity, in which all 10 observed aspects were carried out successfully (100% implementation rate), as well as by the interview with the biology teacher, who stated that the interactive LKPD was easy to implement without requiring complex technical training and successfully increased student engagemnt during the lesson.

The effectiveness of the interactive LKPD was measured based on the change in student's learning motivation, using a questionnaire administered before (pretest) and after (possttest) use of the product.

Table 4. Results of the Student Learning Motivation Questionnaire (pretest and posttest)

No	Student Initials	Pretest Score	Posttest Score
1	A.L	20	37
2	C.S	21	37
3	G.B	22	36
4	G.M	23	38
5	M.I	23	37
6	S.T	22	37
7	V.S	23	37
8	I.L	25	38
total		180	297
Average		22.5	37.1

The results of the learning motivation questionnaire showed an increase in the average score from 22.5 in the pretest to 37.1 in the posttest, with an N-Gain score of 0.83, which was categorized as high. This improvement can be explained by the learning mechanism provided through the inquiry-based interactive LKPD. The inquiry stages required students to actively engage with problems, formulate questions and hypotheses, conduct investigations,

analyze information, and draw conclusions. These activities gave students opportunities to participate directly in the learning process and to construct their understanding of the respiratory system rather than only receiving information. In addition, the interactive features of the LKPD, including instructional videos, interactive exercises, automatic feedback, self-reflection, and an educational word-search activity, provided varied learning experiences and immediate responses to students' work. These features could help maintain students' attention, encourage active participation, and increase their interest in learning. Thus, the increase in learning motivation was not only reflected in the difference between the pretest and posttest scores, but was also associated with the active inquiry process and interactive learning experiences provided by the developed LKPD.

However, the interpretation of the increase in students' learning motivation should be considered within the limitation of the small sample size. The limited trial involved only eight Grade XI students, so the findings primarily describe the responses and learning motivation of the students involved in the trial and cannot be generalized to a broader student population. Therefore, although the increase in motivation and the high N-Gain score indicate positive results, these findings should be interpreted as preliminary evidence of the potential effectiveness of the inquiry-based interactive LKPD. Further trials involving a larger number of students and broader groups are needed to obtain stronger evidence regarding its effectiveness in increasing students' learning motivation.

The material expert validation results, which fall into the very feasible category, reflect that the content of the LKPD aligns

with the scientific concepts of the respiratory system, the learning objectives, and the applicable curriculum principles particularly in the material presentation aspect, which was arranged coherently and integrated effectively with Tsabitah and Raharjo (2023), who argue that a high quality interactive LKPD must align with the curriculum, have clear learning objectives, present material systematically, and use language appropriate to students' cognitive development level. Meanwhile, the media expert validation results, also in the very feasible category, indicate that the interactive features of Liveworksheet such as fill in the blank items, interactive multiple choice questions, and automatic feedback functioned well and supported the learning process. This result is consistent with the studies of Herawati, Gulo, and Hartono and Kalima, Gulo and edi, which state that systematically developing an interactive LKPD using the ADDIE model can produce a product with a high level of validity.

In terms of practicality, students' positive responses regarding readability, alignment of material, and learning motivation indicate that the interactive LKPD was easy to use independently, although the display and design aspect still received suggestions for further development, particularly regarding color variation and illustrations. The teacher interview results further reinforce this quantitative data: students who had previously tended to be passive became more active in asking questions, discussing, and completing assigned tasks after using the LKPD. This finding aligns with the goal of the inquiry approach, which positions students as active subjects in the learning process, as emphasized by Miftah and Rokhman (2022), who state that

systematically designed instructional media can strengthen understanding while also increasing students' learning motivation.

The increase in students' learning motivation from the fairly good category before using the LKPD to the very good category after learning with the inquiry-based interactive LKPD indicates that the developed LKPD was effective in raising students' learning motivation. This increase was driven by the implementation of the inquiry stages, which encouraged students to take an active role in the learning process, from identifying problems and formulating questions to collecting and analyzing information and drawing conclusions independently. In addition, the automatic feedback feature in Liveworksheet gave students the opportunity to immediately see the results of their work, enabling them to reflect and correct their understanding right away. The educational word-search game at the end of the LKPD also helped students recall important terms related to the respiratory system through a more engaging and enjoyable learning activity. This finding is in line with Mayasari (2023), who states that the use of an interactive LKPD equipped with various multimedia features can increase student engagement while strengthening their motivation to participate in the learning process. Overall, the inquiry-based interactive LKPD developed through the ADDIE model met the three main criteria of product quality: validity, practicality, and effectiveness. This finding reinforces previous research by Herawati, Gulo, and Hartono and Kalima, Gulo, and Rodi Edi regarding the effectiveness of interactive LKPDs in improving students' engagement and learning outcomes; however, this study offers an added value by fully integrating

the stages of inquiry-based learning, so that students not only received information but were also actively involved in discovering learning concepts independently.

CONCLUSION

The inquiry-based interactive Student Worksheet (LKPD) developed using the ADDIE model was highly feasible, practical, and showed potential to support students' learning motivation in respiratory system learning. Its scientific contribution lies not only in providing a digital worksheet, but also in integrating systematic inquiry activities, including problem formulation, investigation, data analysis, and conclusion drawing, with interactive features. In practice, teachers need to ensure students' readiness to use the technology and provide appropriate guidance and classroom management during the investigation activities. However, since the limited trial involved only eight students, the findings should be interpreted cautiously and further trials with larger groups are needed.

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