



## Development of electronic students' worksheets based on problem-based learning on air pollution material

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ARTICLE INFO	ABSTRACT
<p><b>Article history</b> Received: 29 February 2024 Revised: 10 October 2024 Accepted: 14 October 2024</p> <p><b>Keywords:</b> Air Pollution Electronic Students' worksheet PBL Learning</p>	<p>This research is development research with the aim to produce teaching material products in the form of PBL-based electronic student worksheets on air pollution sub-materials that will be used during the learning process, so that students can be more active and independent. This type of research is development research using the ADDIE model (analysis, design, development, implementation, evaluation), but this research is limited to the development stage. This research was conducted at State Senior High Schools in Palembang in the 2023/2024 school year. The sample in this study was class X students totaling 12 people. Sampling in this study using purposive sampling technique. electronic student worksheets are designed using the Canva and liveworksheets applications; after completing the design of electronic student worksheets, they are assessed by material and media validators using an instrument in the form of a validation questionnaire. After the electronic student worksheet is declared valid, the electronic student worksheet is applied to students in a small group trial. Based on the validation results with the Kappa calculation, the electronic student worksheets were declared valid with a Kappa value of 1. Electronic student worksheets also fall into the very practical category based on the teacher's practicality questionnaire which obtained a percentage of 100%, while the students' practicality questionnaire obtained an average percentage of 90.68%. Based on the results of the validation and practicality questionnaires of teachers and students, it can be concluded that PBL-based electronic student worksheets are valid and feasible to use during the learning process on air pollution sub-materials.</p>

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## INTRODUCTION

Education is one of the main needs that must be met in human life (Asiyah et al. 2021). Education has a very important role in preparing the next generation of nations that can compete globally in the digital era (Eka et al. 2021). Education can develop the knowledge possessed by humans, from those who initially did not understand to understand, and from those who already understood to understand even more so that with education humans can know what is right and wrong (Fatmawati et al. 2020). Education is also a benchmark for knowing the quality of self that is owned, the higher the education taken, the better the quality it has (Nursafiah et al. 2022).

Education cannot be separated from the curriculum is a major tool that is used as a benchmark in carrying out the education process. The curriculum in Indonesia often changes, curriculum changes aim to face challenges and opportunities so that it can adapt to the times (Suhandi et al. 2022). One of the curricula used now is the Merdeka Curriculum. The Merdeka Curriculum is a curriculum that frees students to acquire knowledge both at school and outside of school comfortably and pleasantly but can show their skills (Rahayu et al. 2022). The Merdeka Curriculum requires students to learn independently to be more active during the learning process so that they can solve the problems they face (Manalu et al. 2022). Apart from students, the Merdeka curriculum also requires teachers to be innovative and creative in developing teaching materials (Sasmita et al. 2022).

Each material is a material consisting of activities and subject matter, arranged in a directed and structured manner based on rules to make it easier for students when following the learning process. Teaching materials consist of various forms, such as textbooks, teaching modules, student worksheets, and others (Magdalena et al. 2020). One of the teaching materials that can be used following the demands of the curriculum is student worksheets. Student worksheets are one of the teaching materials following the demands of the Merdeka curriculum because student worksheets can make students more active both individually and in groups when discussing solutions and answers to problems faced in student worksheets (Harfian & Fadillah, 2022). Student worksheets consist of learning objectives, competencies to be achieved, supporting information, material, and also practice questions that can measure the ability of students (Destiansari et al. 2022). Student worksheets can also adjust the demands and skills to be developed in the Merdeka Curriculum, one of which is problem-solving skills (Astuti et al. 2018). Long with the times, student worksheets can be modified because technology is increasingly sophisticated, so electronic student worksheets are created.

Electronic student worksheets are teaching materials that use Android, laptop, or PC. Electronic student worksheets have advantages and advantages compared to student worksheets, namely, electronic student worksheets can be used anytime and anywhere, electronic student worksheets not only contain subject matter but can contain articles and learning videos so that the learning process is more interesting and students can better understand the subject matter (Indriani & Yogica, 2023). Electronic student worksheets also help teachers to achieve learning objectives (Cholifah & Novita, 2022). Teachers not only develop teaching materials, but also use learning models that are in accordance with the objectives and curriculum.

The learning model that is in accordance with the demands of the Merdeka Curriculum so that students can learn independently and be able to solve problems is the Problem-based learning (PBL) learning model (Mairani et al. 2022). The PBL model used in the learning process can help students learn independently and also generate students' skills to find solutions to problems that have previously been given and directed by the teacher (Andini et al. 2022). PBL-based electronic student worksheets can be used as one of the teaching materials that can develop students' problem-solving skills and also make it easier for students to learn the material so that they can master the concept of learning biology, especially air pollution sub-materials (Astuti et al. 2018).

PBL-based electronic student worksheets are appropriate for use in air pollution sub-matter because this material is directly related to the lives of students. Air is often polluted due to human activities such as burning garbage, factory fumes, and vehicles. According to (AQI, 2023) on September 21, 2023, Indonesia is one of the countries with the highest level of air pollution, Indonesia occupies the third position with an air index of 129 AQI US, meaning that this pollution is unhealthy for sensitive groups. On September 21, 2023, Palembang city occupied the first position with a very high level of air pollution, the air pollution index in Palembang City reached 162 US AQI, this condition is marked as an unhealthy or dangerous warning for health, so people are strongly encouraged to use masks when outside the home and reduce outdoor activities. Air pollution related to the real life of students is one

of the reasons researchers develop PBL-based electronic student worksheets on air pollution sub-materials, because with the PBL-based electronic student worksheets students have the freedom to conduct investigations both inside and outside the classroom to find solutions to the problems being faced (Fitriyah & Ghofur, 2021). Environmental problems related to the daily lives of students are the reason for researchers to develop PBL-based E-LKPD on air pollution sub-materials. E-LKPD has many advantages and benefits compared to printed LKPD, one of the benefits of E-LKPD is that it makes learning more interactive and effective, in contrast to printed LKPD which is less interactive when used in the learning process. Research conducted by (Putri et al. 2023), namely developing PBL-based LKPD on environmental changes regarding global warming, the weakness of this study is that the products developed are still in printed form. The use of LKPD during the learning process requires a lot of funds to print LKPD, besides that its use is less interactive because students only fill in printed LKPDs containing question exercises. LKPD should be equipped with articles, learning videos and supporting website links so that students can develop problem-solving skills that are relevant to their lives during the learning process.

Theory and facts in the field are often different. Based on interviews with biology teachers, during the learning process teachers more often use printed books and very rarely use teaching materials in the form of electronic student worksheets. In addition to teaching materials, teachers also rarely use PBL learning models because during the learning process teachers more often use the lecture method. This makes students passive and less able to find solutions to solve real problems that exist in everyday life, because during the learning process students' ability to solve problems is not improved or developed. As is well known, the Merdeka Curriculum requires students to be active during the learning process and have skills in problem-solving (Kainama et al. 2023). These problems become a reference for researchers in developing PBL-based electronic student worksheets on air pollution sub-materials that are more interactive than previous electronic student worksheets. Based on the background previously described teaching materials in the form of PBL-based E-LKPD were developed. The existence of this development aims to enable students to use interactive teaching materials so that the learning process becomes more enjoyable as well as to improve problem-solving skills by using teaching materials in the form of PBL-based E-LKPD.

## **METHODS**

### **Research Design**

This study used a development research design using the ADDIE model developed by Dick and Carey 1996. The ADDIE model consists of five interrelated stages, namely analysis, design, development, implementation, and assessment (Rahayu et al. 2022). This research is limited to the development stage only due to the limited number of students in the product trial, so that the implementation and evaluation stages cannot be carried out.

### **Population and Samples**

The population in this study were high school X-grade students. The sample used in this study was X.7 class students totaling 12 students. The sampling technique in this study used Purposive Sampling technique. Purposive sampling is a sampling technique by considering certain things (Sugiyono, 2013). Researchers made class X.7 as a sample in this study, because based on the results of interviews with biology teachers, class X.7 students tend to be passive when following the learning process so that they have less cognitive abilities compared to other classes.

### **Instrument**

The methods used in data collection are expert validation instruments and practicality instruments for teachers and students. Expert validation was carried out by two expert lecturers, namely material experts and media experts. Product validation is carried out as a requirement before the product developed is tested on students. The purpose of validation is to receive suggestions and input regarding the product developed to produce a product that is valid and suitable for use (Rizanti et al. 2023). Expert validation uses an instrument in the form of a validation questionnaire. The material validation questionnaire consists of two aspects, namely content or material and learning aspects, while the media validation questionnaire consists of four aspects, namely design quality, display quality, readability, and efficiency of use. The material and media validation questionnaires each consist of 15

statements, the assessment of the material and media validation questionnaires uses a Guttman scale with the answer options agree and disagree.

In addition to expert validation questionnaires, researchers also use teacher and learner practicality questionnaires. The practicality questionnaire was given to one biology teacher and also to 12 students. The teacher and learner practicality questionnaires each consisted of 20 statements with the same aspects. The teacher and learner practicality questionnaire consists of six aspects, namely practicality, content or material, readability, media quality, benefits and efficiency of use. The practicality questionnaire assessment score uses a Likert scale with five points. The Likert scale is the scale most often used to see the perspectives, opinions and attitudes of individuals or a group about social events that are happening (Pranatawijaya et al. 2019).

## **Procedure**

This research is research that develops or produces teaching material products in the form of PBL-based electronic student worksheets on the sub-material of air pollution. This research refers to the stages of the ADDIE model consisting of five interrelated stages. The first stage of this research is the analysis stage, in the analysis stage the researcher carries out a curriculum analysis to find out the curriculum used and the depth of the material, then the researcher analyzes the needs of students to find out the learning models and learning methods used by teachers during the learning process, as well as difficulties or problems faced by students during the learning process, finally the researcher analyzed the learning objectives as a reference for researchers to develop teaching materials in the form of PBL-based electronic student worksheets that will be used during the learning process on the air pollution sub-material. The second stage of this research is design. Researchers designed electronic student worksheets using the Canva application. The design of the electronic student worksheet includes the cover, contents and other parts contained in the electronic student worksheet. The third stage, namely development, researchers developed an electronic student worksheet that had been designed using the Canva application into one part in PDF form, then the PDF was inserted into the liveworksheets website to add elements such as answer columns, YouTube links and air quality information website links. After the electronic student worksheet has been developed, the electronic student worksheet is validated by material experts and media experts to determine the validity of the product developed using a validation instrument by paying attention to several aspects, namely content aspects which include the quality of content or material and learning and media aspects which include design quality, display quality, legibility, and efficiency of use.

After the electronic student worksheet is validated and declared valid, the electronic student worksheet can be applied to students. The application of electronic student worksheets was carried out with limited small group trials of 12 students from class X.7. A trial was carried out to see students' responses regarding the practicality of the PBL-based electronic student worksheets that had been developed. After the trial, each student and teacher were given a practicality questionnaire. The teacher and student practicality questionnaire grids include practicality, content/material, readability, media quality, benefits, and efficiency of use.

The practicality questionnaire grids for teachers and students measure the same aspects, because in the learning process teachers and students use the same electronic student worksheets even though the contents of the teacher's electronic student worksheets are slightly different from the contents of the students' electronic student worksheets.

## **Data Analysis Techniques**

The data in this research was analyzed qualitatively and quantitatively. Qualitative data analysis was obtained through the results of curriculum analysis, analysis of student needs, analysis of learning objectives, suggestions and input from material expert validation and media expert validation. Quantitative data analysis was obtained by calculating the results of material and media validation questionnaires using Kappa coefficient calculations. The practicality response questionnaire for teachers and students uses a five-point Likert scale, with assessment criteria, namely 5 strongly agree, 4 agree, 3 disagree, 2 disagree, 1 strongly disagree. Material and media expert validation analysis was calculated using Kappa calculations (Viera & Garrett, 2005).

**Table 1.**

Validation from Validators

Expert 2	Expert 1		Total
	Agree	Disagree	
Agree	a	b	M <sub>1</sub>
Disagree	c	d	M <sub>2</sub>
Total	N <sub>1</sub>	N <sub>2</sub>	N

Information:

a = The number of statements if both validators agree

b = Number of statements if validator 1 disagrees, but validator 2 agrees

c = Number of statements if validator 1 agrees, but validator 2 disagrees

d = Number of statements if both validators disagree

N<sub>1</sub> = (a+c)N<sub>2</sub> = (b+d)M<sub>1</sub> = (a+b)M<sub>2</sub> = (c+d)

N = Total

**Table 2.**

Kappa Interpretation

Kappa Coefficient	Interpretation
0.01 – 0.20	Bad
0.21 – 0.40	Enough
0.41 – 0.60	Currently
0.61 – 0.80	Good
0.81 – 0.99	Almost perfect
1	Perfect

If the Kappa coefficient value is less than 0.61 then the PBL-based electronic student worksheet in the air pollution sub-material is invalid and not suitable for use so it needs revision, however if the Kappa coefficient value is more than 0.61 then the PBL-based electronic student worksheet is declared valid and suitable for use. Apart from validation analysis, researchers also carried out practical analysis for teachers and students. Analysis of the practicality of teachers and students uses a Likert scale, with the following formula.

$$P = \frac{\sum X}{N} \times 100\%$$

Information:

P = Percentage

Σx = Total number of scores obtained

N = Maximum number of scores

Interpretation of the teacher and student practicality questionnaire analysis refers to the Table below

**Table 3.**

Questionnaire Assessment Conversion

Percentage (%)	Criteria
80 ≤ Nilai ≤ 100	Very practical
60 ≤ Nilai ≤ 80	Practical
40 ≤ Nilai ≤ 60	Quite practical
20 ≤ Nilai < 40	Not practical
0 ≤ nilai < 20	Not practical

Source: Sudijono (2016)

**RESULTS AND DISCUSSION**

This research produces teaching material products in the form of PBL-based electronic student worksheets on the sub-material of air pollution in class X in senior high school. The research refers to the ADDIE model with five stages, namely analysis, design, development, implementation and evaluation, but is limited to the development stage only. The steps for the ADDIE model will be explained



as follows. The first stage of this research is analysis. The analysis is divided into three, namely curriculum analysis, student needs and learning objectives which can be seen in the table below.

**Table 4.**

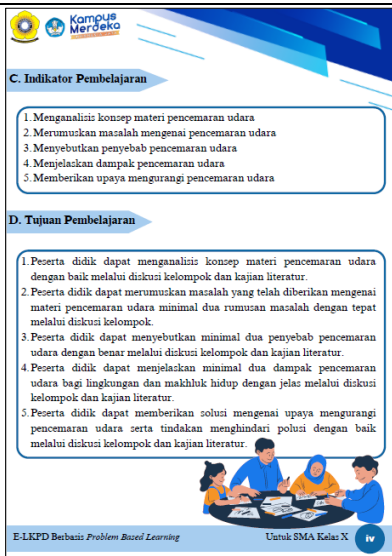
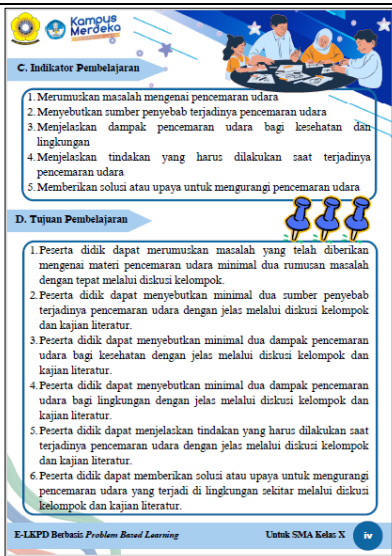
Analysis stages in the ADDIE model

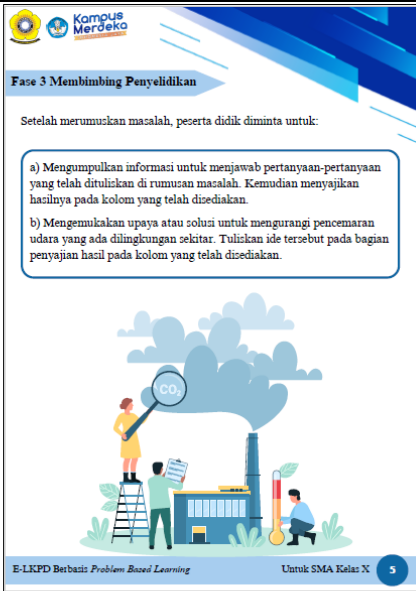
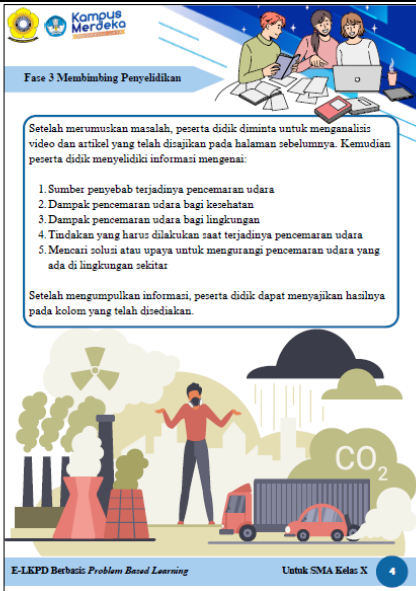
No	Analyze	Information
1	Curriculum	In the curriculum analysis, it is known that SMA Negeri 16 Palembang uses the Merdeka curriculum in class X. Environmental change material is included in the even semester lesson material for the 2023/2024 academic year. Development of limited electronic student worksheets with air pollution as a sub-material.
2	Students' Need	<p>The aim of analyzing student needs is to explore in-depth information about students' problems and needs during the learning process (Supriatin et al. 2022). Based on interviews with biology teachers and student needs questionnaires, the following analysis of student needs was obtained:</p> <ol style="list-style-type: none"> <li>1. Most students do not know about teaching materials in the form of electronic student worksheets</li> <li>2. Most students do not know the Problem Based Learning (PBL) learning model</li> <li>3. Teachers more often use lecture and discussion learning methods</li> <li>4. Teachers rarely use the PBL learning model during the learning process</li> <li>5. Teachers very rarely use teaching materials in the form of electronic student worksheets</li> <li>6. Teachers more often use teaching materials in the form of printed books and published student worksheets</li> <li>7. Based on the needs questionnaire, most students need PBL-based electronic student worksheets so that the learning process becomes more effective and interactive. In addition, PBL-based electronic student worksheets can help students improve problem solving skills.</li> </ol>
3	Learning Objectives	Researchers analyzed the learning objectives based on phase E learning achievements, then adjusted them to the air pollution sub-material so that the learning objectives were implemented during the learning process.

The second stage is to design the electronic student worksheet using the Canva application and also Liveworksheet. The contents of electronic student worksheets refer to PBL syntax which consists of five stages, namely problem orientation, organizing students, guiding investigations, presenting and developing work results and analyzing and evaluating the problem-solving process (Sutirman, 2013). Electronic student worksheets that have been designed using the Canva application are then put together in PDF form; then, the PDF is inserted into the Liveworksheet website to add several elements such as answer boxes, learning videos and the air quality index website.

The third stage is development. At this stage, the electronic student worksheets that have been designed are validated by two experts, namely a material expert and a media expert. The validator looks at the product design and then provides suggestions, input and responses in the form of a validation questionnaire. The material and media validation questionnaire each consists of 15 questions. The following are improvements to PBL-based electronic student worksheets based on suggestions and input provided by material and media validators which can be seen in Table 5.

**Table 5.**  
Results of Improving Electronic Student Worksheets

No	Before	After
1	 <p>Before the revision, learning indicators consisted of five, namely:</p> <ol style="list-style-type: none"> <li>1. Analyze the concept of air pollution material</li> <li>2. Formulate problems regarding air pollution</li> <li>3. Mention the causes of air pollution</li> <li>4. Explain the impact of air pollution</li> <li>5. Providing efforts to reduce air pollution</li> </ol> <p>Before being revised, the learning objectives consisted of five points, namely as follows:</p> <ol style="list-style-type: none"> <li>1. Students can analyze the concept of air pollution material well through group discussions and literature studies.</li> <li>2. Students can formulate the problem that has been given regarding pollution material in at least two problem formulations correctly through group discussions.</li> <li>3. Students can name at least two causes of air pollution correctly through group discussions and literature review.</li> <li>4. Students can explain at least two impacts of air pollution on the environment and living things clearly through group discussions and literature review.</li> <li>5. Students can provide solutions regarding efforts to reduce air pollution and actions to avoid pollution properly through group discussions and literature studies.</li> </ol>	 <p>Learning indicators after being improved based on validator suggestions and input</p> <ol style="list-style-type: none"> <li>1. Formulate the problem regarding air pollution</li> <li>2. Mention the sources that cause air pollution</li> <li>3. Explain the impact of air pollution on health and the environment</li> <li>4. Explain the actions that must be taken when air pollution occurs</li> <li>5. Providing solutions or efforts to reduce air pollution</li> </ol> <p>After repair, it consists of six points, namely:</p> <ol style="list-style-type: none"> <li>1. Students can formulate the problem that has been given regarding air pollution material in at least two problem formulations correctly through group discussion</li> <li>2. Students can clearly state at least two sources that cause air pollution through group discussions and literature review</li> <li>3. Students can clearly state at least two impacts of air pollution on health through group discussions and literature review</li> <li>4. Students can clearly state at least two impacts of air pollution on the environment through group discussions and literature review</li> <li>5. Students can clearly explain the actions that must be taken when air pollution occurs through group discussions and literature review</li> <li>6. Students can provide solutions or efforts to reduce air pollution that occurs in the surrounding environment through group discussions and literature studies.</li> </ol>

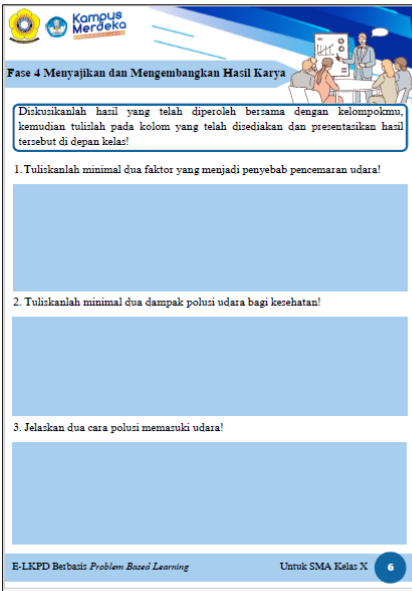
No	Before	After
2		

In phase three, guiding the investigation, the command sentences for students are too ambiguous and have broad meaning so that they can make it difficult for students to find information.

After validation, the command sentences are more detailed so that students can find specific information. In this phase students are asked to search for or investigate information about

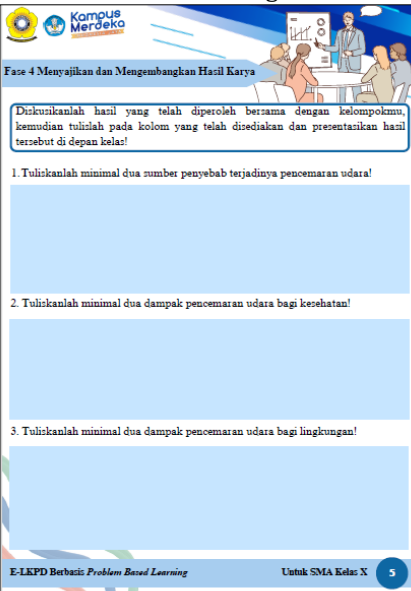
1. Source of air pollution
2. The impact of air pollution on health
3. the impact of air pollution on the environment
4. Actions that must be taken when air pollution occurs
5. Looking for solutions or efforts to reduce air pollution in the surrounding environment

3



Before revising the electronic student worksheet has the following five questions:

1. Write down at least two factors that cause air pollution!
2. Write down at least two impacts of air pollution on health!
3. Explain two ways pollution enters the air!
4. Explain the two types of pollutants that cause air pollution
5. Discuss with your group about:



After being repaired the electronic student worksheet has the following five questions:

1. Write down at least two sources that cause air pollution!
2. Write down at least two impacts of air pollution on health!
3. Write down at least two impacts of air pollution on the environment!
4. Write down the actions that must be taken to avoid air pollution when air pollution occurs



No	Before	After
a.	Write down at least two efforts that can be taken to reduce the impact of air pollution on health and the environment!	5. Write down solutions or efforts that can be made to reduce air pollution in the surrounding environment!
b.	b. Write down at least two actions that must be taken to avoid air pollution!	

After providing suggestions and input, the validator assesses the product using a validation questionnaire. The validation questionnaire was calculated using the Kappa coefficient. The following are the calculation results of the two validators which can be seen in [Table 6](#).

**Table 6.**  
Validator assessment results

Validator 2	Validator 1		Total
	Agree	Disagree	
Agree	15	0	15
Disagree	0	0	0
Total	15	0	15

The results obtained through calculating the Kappa coefficient are 1 with a very perfect category. The product can be used if the Kappa coefficient value is greater than 0.61 following the Kappa interpretation listed in [Table 4](#). Based on the results obtained, the PBL-based electronic student worksheet is declared valid and suitable for use. The electronic student worksheet has completed the parts and requirements for a good and correct electronic student worksheet. The sections in the electronic student worksheet include the title of the electronic student worksheet, instructions for use and study instructions, learning outcomes, lesson materials, supporting information, and practice questions to measure students' abilities and assessment (Asmaranti et al. 2018). The requirements for electronic student worksheets that are correct and good according to Indriyani (2013) which are appropriate based on expert validation include three requirements, namely 1) didactic requirements, electronic student worksheets pay attention to students who have various kinds of differences both in terms of understanding the concept of the material and in terms of attitudes and behavior, 2) construction requirements, it is better for electronic student worksheets to use language that is clear, easy to understand following the level of education taken by students, so that all students can understand each sentence stated in the student worksheet electronics to achieve learning objectives, 3) technical requirements, electronic student worksheets have an attractive appearance so that students feel interested and happy when using electronic student worksheets during the learning process.

Products that have passed the validation process and been declared valid are then tested in a small group of 12 students. The trial was carried out to know students' responses regarding the practicality of PBL-based electronic student worksheets. After using and working on PBL-based electronic student worksheets, students are given a practicality questionnaire consisting of 20 statements. The results of the student practicality questionnaire can be seen in [Table 7](#).

**Table 7.**  
Results of the practicality questionnaire for PBL-based electronic student worksheets by students in small group trials

No	Aspect	$\Sigma x$	N	Percentage (%)	Criteria
1	Practicality	259	300	86.33	Very practical
2	Content/Material	165	180	91.67	Very practical
3	Legibility	112	120	93.33	Very practical
4	Media Quality	110	120	91.67	Very practical
5	Benefit	270	300	90.00	Very practical
6	Efficiency of Use	164	180	91.11	Very practical
Average				90.68	Very practical

**Information**

$\Sigma x$  : Total number of scores obtained

N : Maximum number of scores

Apart from students, a practical questionnaire was also given to biology teachers to see and find out teachers' responses regarding PBL-based electronic student worksheets. The following are the results of the teacher practicality questionnaire calculations which are shown in [Table 8](#).

**Table 8.**

Results of a questionnaire on the practicality of PBL-based electronic student worksheets by teachers

No	Aspect	$\Sigma x$	$N$	Percentage (%)	Criteria
1	Practicality	25	25	100	Very practical
2	Content/Material	15	15	100	Very practical
3	Legibility	10	10	100	Very practical
4	Media Quality	10	10	100	Very practical
5	Benefit	25	25	100	Very practical
6	Efficiency of Use	15	15	100	Very practical
Average				100	Very practical

### Information

$\Sigma x$  : The total number of scores obtained

$N$  : Maximum total score

The teacher practicality questionnaire has the same number of questions and aspects as the student practicality questionnaire. Based on the results of the teacher practicality questionnaire, a percentage of 100% was obtained in the very practical category, while the students' practicality questionnaire obtained an average percentage of 90.68% in the very practical category. It can be concluded that PBL-based electronic student worksheets are practical to use in the learning process. This statement is proven by research conducted by Subakti et al (2021) which states that valid and practical products are products with good quality so they can be used during the learning process.

Electronic student worksheets using the liveworksheets website have several advantages, namely making it easier for students to do practice questions without rewriting them in books, being able to access information about air quality via the website link that has been provided and being able to access learning videos without using other applications so that the learning process is more effective and interactive (Dwiyanti et al. 2023). PBL-based electronic student worksheets also have benefits for students, namely they can provide motivation, enthusiasm for learning, increase curiosity, make students active and independent when learning, and help students understand the lesson material well (Indriani et al. 2022). Electronic student worksheets can also make the learning process interactive, effective, interesting and flexible because they can be done anywhere and at any time so they can improve the quality of learning (Pamungkas & Kusdiwelirawan, 2020).

The PBL model in electronic student worksheets allows students to explore knowledge independently, experiment, find solutions or efforts, and solve problems independently. This is proven by research conducted by Hidayanti et al (2023) which states that the PBL model can improve solving abilities, because the PBL model is a model that requires students to be more active and independent during the learning process and find answers to problems that have been presented by them. teachers both individually and in groups. The PBL model provides opportunities and experience for students to find real problems, the PBL model also encourages students to be able to discuss, work together to put forward ideas to improve reasoning and problem solving skills (Ummu & Usman, 2023). The PBL model refers to students' cognitive skills, therefore the learning process is not only centered on the activities carried out by students but is centered on what students are thinking while participating in learning activities (Anggraini et al. 2022).

It is hoped that the PBL-based electronic student worksheet on the air pollution sub-material can enable students to understand the air pollution sub-material better. Students who understand the subject matter well can participate in providing efforts or solutions to prevent and reduce air pollution from getting worse in the surrounding environment. PBL-based electronic student worksheets are also expected to be able to improve students' problem-solving skills regarding issues currently occurring in Indonesia (Nining et al. 2023).

### CONCLUSION

PBL-based electronic student worksheets are products that are valid and suitable for use. This is proven by the validation results of material experts and media experts who obtained a Kappa coefficient value of 1 in the very perfect category. PBL-based electronic student worksheets were also

declared practical based on teacher and student practicality questionnaire calculations. The teacher's practicality questionnaire obtained a percentage result of 100% in the very practical category, while the student's practicality questionnaire obtained a percentage of 90.68%. From the results of the validation and practicality questionnaire, the PBL-based electronic student worksheet on the air pollution sub-material is a valid and very practical product so it is suitable for use in the learning process for the air pollution sub-material.

## ACKNOWLEDGMENT

The author would like to thank the Biology Education Study Program, Faculty of Teacher Training and Education, Sriwijaya University, teachers and students as well as those who have helped complete this research.

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