Electronic Student Worksheet for Solving Problems in Physics Material Based on Problem-Based Learning

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***Abstract*—In the learning process, the learning objectives can be achieved if students are actively engaged in the learning activities. The level of student engagement in learning can be observed through their participation in expressing opinions, taking responsibility, and involvement in group learning. Therefore, it is essential to have teaching materials that can make students actively participate, serve as tools in the learning process, and be used as learning resources. One of these tools is the e-student worksheet. However, the e-student worksheets available in schools often focus more on questions and problem-solving without explaining how the answers to those questions are obtained. Hence, there is a need for the development of e-student worksheets aimed at understanding the stages involved in creating problem-based learning-based on the topic of dynamic fluids for grade XI students in high school. This development is intended to determine the suitability of the e-student worksheet for use as teaching material and to assess the students' response to problem-based learning-based e-student worksheets. This research was conducted at SMA N 1 Lubuk Sikaping, with grade XI students as the research subjects. The research method used is based on the Analysis Design Development Implementation Evaluation (ADDIE) model of development. The instruments used for the research include validation sheets and questionnaires. Based on data analysis, it can be concluded that the quality of the developed e-student worksheet fits within the "valid" category, making it suitable for use with a rating of 0.88 from the experts. The response from teachers showed a 94% acceptance rate, and the response from students showed a 90% acceptance rate, both categorized as "very practical." Both components received average scores exceeding the acceptable threshold, indicating that the developed e-student worksheet can be used as a reference in fulfilling teaching materials.**

***Keywords*—e-student worksheet, problem based learning, Analysis Design Development Implementation Evaluation (ADDIE) model, physics**

I. Introduction

In the world of education, information technology plays a crucial role in supporting the learning process. In general, information technology contributes to making education more productive, empowering, up-to-date, and engaging [1]. By using technology as a learning tool and the internet as a learning medium, learners can quickly access information anytime and anywhere [2]. However, currently educational landscape, the utilization of information and communication technology remains quite limited. Many schools in Indonesia still follow conventional teaching systems, which can diminish students' interest in learning. Therefore, teachers need to innovate their teaching methods to keep students motivated. One of the strategies to boost students' motivation is to use appropriate and effective teaching materials [3].

Traditional paper-based teaching materials are gradually being replaced because excessive paper usage can lead to deforestation [4]. With advancements in science and technology, the use of paper as a printing medium and teaching material is being phased out (going paperless) [5]. One practical application of this trend is the development of paperless teaching materials, which not only enhances the quality of education but also reduces natural resource consumption. These challenges emphasize the importance of developing e-student worksheets for the instructional model to be implemented in senior high schools.

In the 2013 curriculum, learning should be conducted with an inquiry-based approach, emphasizing critical thinking, problem-solving skills, and collaboration. The characteristics of 21st-century education demand that learners possess high-level thinking skills, including critical thinking. As teachers face the challenges of 21st century, they must better prepare students to become investigators, problem solvers, critical thinkers, and creative individuals [6]. The challenge of 21st-century learning is that learners must be able to develop critical thinking skills to solve real-world problems. Effective learning requires a model that can strengthen the scientific approach, allowing students to solve problems creatively and innovatively [7].

The appropriate instructional model for fostering 21st-century skills is problem-based learning. The implementation of problem-based learning enhances students' critical thinking abilities [8]. Problem-Based Learning (PBL) is one of the recommended instructional models in the 2013 curriculum. Implementing PBL can improve students' problem-solving skills and critical thinking abilities. Critical thinking skills encourage learners to respond sensitively to the issues they encounter [9].

Efforts to enhance 21st-century competencies are being emphasized in grade XI of senior high school. These efforts include curriculum development and improvement, evaluation system enhancement, improvement of educational facilities, development and procurement of teaching materials, training and improvement of lecturer quality, and higher education management quality enhancement [10]. Additionally, strategies are being developed to expand educational opportunities and training for young people who are less productive [11]. Improving the quality of education includes curriculum refinements, teacher competency enhancements, and infrastructure improvements.

The development of e-student worksheets must be carefully designed, recognizing the importance of teaching materials as learning facilitators. Student learning outcomes

are significantly influenced by the choice of teaching materials [12]. Therefore, developing e-student worksheets based on student input is an effective way to gather valid data before determining the e-student worksheets to be developed. E-student worksheets are learning tools that can be used to support the teaching and learning process [13]. They are intended to enhance the teaching and learning process, which is why easily accessible teaching materials are required. This is why non-print media, such as electronic e-student worksheets, are needed [14].

A e-student worksheet is teaching material that contains summary material and instructions for learning tasks to be carried out by students with reference to basic competencies and intended learning outcomes [15]. E-student worksheets contain a set of fundamental activities that students must perform to maximize their understanding, aligned with the indicators of learning outcomes [16]. E-student worksheets are a learning resource that consists of sheets containing material, summaries, and instructions for learning tasks to be carried out by students. Using e-student worksheets as a learning medium is an alternative to optimizing concept comprehension and student learning activities [17]. Technically, a e-student worksheet comprises six elements: title, instructional guidelines, basic competencies or core material, supporting information, and tasks or steps to complete the work [18].

A shift in perspective on students from being objects to subjects in the learning process has led to innovative approaches in 21st-century education. Teachers are expected to select teaching models that motivate students to actively engage in their learning experiences. One alternative model that enhances thinking skills (reasoning, communication, and connection) for solving problems is problem-based learning [19]. Problem-based learning is a model that challenges students to learn cooperatively within a group to solve real-world problems. It prepares students to think critically, analytically, and creatively, using various sources.

In problem-based learning, teachers play the role of facilitators, preparing students' thinking tools, emphasizing cooperative learning, and connecting the problems discussed with the existing curriculum. Problem-based learning is a cooperative learning method in which students can more easily discover and understand difficult concepts by discussing these problems with their peers [20].

Based on the background and theoretical overview above, this research aims to obtain data, information, and analysis regarding: (1) the need for problem-based learning-based worksheets in grade XI of senior high school; (2) the validity of problem-based learning-based worksheets; and (3) the practicality of problem-based learning-based worksheets. Referring to the ADDIE development model, this research is only carried out until the implementation stage. This research is expected to serve as a reference for obtaining data about the analysis of the needs, validity, and practicality of worksheets in grade XI of ssenior high school.

II. Method

The Analysis Design Development Implementation Evaluation (ADDIE) research and development model consists of five stages [21], which are analysis, design, development, implementation, and evaluation. The research and development work conducted is limited to the implementation stage, which involves testing the product on a small group.

A. Analysis

The analysis stage is the process of gathering information that can be used as material for creating a product. Needs analysis consists of three types of analysis, including:

1) Analyzing learning problems to identify issues in the learning process

The first stage of research is conducting interviews. The interviewee is an 11th-grade teacher. The interview topics include two areas: e-student worksheets and the curriculum. The e-student worksheet topic encompasses questions about the availability of e-student worksheets, the frequency of their use, and common issues that arise along with their expectations. In the curriculum topic, there are questions related to the applied curriculum, frequently used teaching methods, curriculum-related issues, and the materials that require the development of e-student worksheets.

2) Analyzing students to understand their learning needs

The next stage involves filling out a questionnaire for analysis by 11th-grade students. The purpose of filling out this questionnaire is to understand the students' opinions regarding the e-student worksheets they need. The questionnaire topics include materials that require e-student worksheets, the type of e-student worksheets needed, and the elements required in e-student worksheets.

The needs analysis questionnaire uses the Guttman scale, which is a scalogram scale that is very effective in ensuring research results. Students' answers of "yes" are assigned a value of "1," and "no" is assigned a value of "0" for the questionnaire's answer alternatives. This research takes the form of a checklist using the Guttman scale. Subsequently, the results are quantitatively analyzed in the form of percentages. The following is the formula for calculating the percentage of data that needs analysis.

$$P = \frac{f}{n} \times 100\% \quad (1)$$

where:

P = Percentage;

f = Frequency;

n = Total responses.

The categories for interpreting the results of the needs analysis percentage are obtained from the modified research findings [22]. These categories are presented in Table 1.

Table 1. Percentage categories

Percentage	Category
0–1.9%	Not needed
2%–25.9%	A small portion needs it
26%–49.9%	Less than half needs it
50%	Half needs it
50.1%–75.9%	More than half needs it
76%–99.9%	A significant portion needs it
100%	Everyone needs it

The quantitative results of the questionnaire are interpreted in accordance with Table 1. If the results show a percentage

equal to or greater than 50%, it can be concluded that e-student worksheets are needed. If the percentage is less than 50%, it indicates that the development of e-student worksheets is not necessary. Descriptive results present an overview of the entire analysis stage, including descriptions of the interpretation of the questionnaire, feedback, and comments provided by the students in the questionnaire.

3) Analyzing the learning process to obtain field data from perspectives other than teachers and students

Observation activities are carried out during the teaching process. The purpose of observation is to gather firsthand data from a perspective other than that of the teacher and students.

B. Design

There are four elements to consider at this stage specifically: 1) Designing the components of the worksheet; 2) Designing the content/material of the worksheet; 3) Designing the appearance/layout of the worksheet; 4) Designing the instruments/tools.

C. Development

The design of the e-student worksheet must be validated by experts before it is piloted. This is done to determine the reliability of its components. The instrument used to assess the validity of the product development is a validation questionnaire for the e-student worksheet by experts. The validation questionnaire from the experts is designed based on predetermined indicators for the e-student worksheet. The instrument framework is derived from the components of suitability [23]. The instrument to be created consists of several components, including substance, design, visual appearance, software utilization, and the problem-based learning model. Table 2 shows the criteria based on values for evaluating the validity of the e-student worksheet [24].

The Aiken's V validity formula will be employed to assess the validity of the questionnaire provided by the validator.

$$V = \frac{\sum s}{n\,(c-1)} \tag{2}$$

where:

V = index of agreement on item validity;

s = the assigned score minus the lowest score. The category used, where r is the validator's preferred score, and $I0$ is the lowest score in the scoring category;

$\sum s$ = scores;

n = number of validators;

c = number of categories chosen by the validator [25].

The criteria for assessing validity using Aiken's V scale are provided below [26].

Table 2. Assessment categories for validity

Percentage	Category
75%–100%	Valid
50%–74%	Valid Enough
25%–49%	Less Valid
0–24%	Invalid

Validators can assess claims on the validator leverage sheet by choosing from four categories. Table 3 illustrates the division of the validator selection categories into four groups.

Table 3. Assessment categories for validator responses

Percentage	Category
0–25%	Strongly disagree
26%–50%	Disagree
51%–75%	Agree
76%–100%	Srongly Agree

In the art category, a validator can assign a maximum score of 4 (agree) or a minimum score of 1 (strongly disagree). At this stage, six specialists are required to serve as validators. Aiken's V scale is used as the validity criteria throughout the expert review phase. The validity criteria using the Aiken's V scale are displayed in Table 4.

Table 4. Assessment categories for validity

Value	Category
<0.78	Invalid
≥0.78	Valid

A validation instrument analysis can produce a minimum value of 0.00. Each validator assigns a score of 0.00 to the same statement if they strongly disagree with it. Conversely, if a validator fully agrees with a claim, they assign it the highest rating of 1.00. This scale allows for a spectrum of responses, with 0.00 indicating strong disagreement and 1.00 indicating strong agreement.

Each step's revisions are determined by the total value of all the categories. It also takes into account recommendations and remarks made.

D. Implementation

After testing the validity of the e-student worksheet, the practicality of the e-student worksheet is evaluated. The instrument used to assess practicality is a practicality test questionnaire from practitioners. The practicality test questionnaire to be used includes questionnaires on practicality, according to teachers and students. The practicality test questionnaire for teachers and students is used to gauge the feedback of teachers and students regarding the content, visual appearance, and ease of use of the e-student worksheet. The practicality test questionnaire for teachers and students is also designed according to the indicators set for the use of the e-student worksheet. Table 5 contains the standards for evaluating practicality [27].

The following equation will be used to assess the results of the small group practicality evaluation questionnaire:

$$x_i = \frac{\sum s}{s_{\max}} \times 100\% \tag{3}$$

where:

x_i = value of questionnaire for each aspect;

$\sum s$ = scores;

S_{max} = maximum score.

Table 5. Practicality criteria use Likert scale

Percentage	Category
81%–100%	Very practical
61%–80%	Practical
41%–60%	Practical enough
21%–40%	Less practical
≤20%	Not practical

III. Results

The ADDIE model is a framework that serves as a guide for elaborating effective, dynamic, and self-directed learning [28]. This model is one of the most widely used models in instructional design, resulting in effective designs [29]. Here are the stages of the ADDIE model.

A. Analysis

The first result is in the form of the findings in the needs analysis stage. The results of the needs analysis describe the issues found in the field and alternative solutions related to these issues. The results of the needs analysis stage were obtained through questionnaire techniques, interviews, and observation activities conducted at the senior high school. The results of the needs analysis stage are as follows:

1) Analyzing learning problems to identify issues in the learning process

The analysis of learning problems describes the issues encountered during the learning process. Learning problems in senior high school are related to the need for e-student worksheets in 11th-grade classrooms and are divided into two topics. The interview topics cover e-student worksheets and the curriculum used. The indicators used for the topic of e-student worksheets include questions about the availability of e-student worksheets, the frequency of their use, common issues that arise, and expectations. For the curriculum topic, there are questions related to the applied curriculum, frequently used teaching methods, curriculum-related issues, and the materials that require the development of e-student worksheets.

2) Analyzing students to understand their learning needs

The analysis of students includes the completion of a questionnaire for needs analysis by 11th-grade students. The purpose of filling out this questionnaire is to understand students' opinions regarding the worksheets they need. The topics covered in this questionnaire include the subjects that require worksheets, the types of worksheets needed, and the elements required in the worksheets. The results of the questionnaire filled out by students are presented in Table 6.

Table 6. The results of needs analysis questionnaire

Indicator	Value	Percentage
The learning material that requires it is the topic of dynamic fluids.	69	79.3%
The type of e-student worksheet is in electronic form.	147	84.5%
The e-student worksheet is based on Problem-Based Learning.	72	82.7%
The elements needed include alignment with learning objectives (KD), reinforcement of the material, animations, videos, simulations, and audio.	133	91.7%
Average		84.5%

These results indicate that the average percentage is 84.5. When interpreted according to Table 1, it falls within the percentage range of 76% to 99.9% and is categorized as the majority needing e-student worksheets.

3) Analyzing the learning process to obtain field data from perspectives other than teachers and students

The analysis of the learning process includes observation activities conducted during the actual teaching sessions. The purpose of observation is to gather authentic field data from a perspective other than that of the teacher and students. Observation results are obtained after an observer has attended a single teaching session, following the entire lesson from the introduction to the conclusion. These observation results provide insights into the teaching process from a perspective other than that of the teacher and students themselves. Therefore, it is expected that the needs analysis data will be more comprehensive and targeted from various viewpoints.

The observation results indicate that the teaching process is still conventional. Intensively used e-student worksheets are primarily those created by the teacher. Additionally, teachers only use readily available media, such as LCD screens and computers, to display images or instructional videos. The use of other e-student worksheets is very rare.

B. Design

The next stage is to carry out the design or planning to develop the e-student worksheet. This stage is done to facilitate the product development process. The design of the product is carried out through four processes, specifically:

1) Designing the components of the worksheet

In this design phase, the contents of all the components needed in the worksheet will be prepared. The components within the worksheet include the cover, introduction, table of contents, subject identification, introduction, worksheet 1, worksheet 2, evaluation, bibliography, and author information. Planning for each component's content will facilitate the development of the worksheet product. The components of the worksheet are illustrated in the table of contents, as seen in Fig. 1.

Fig. 1. Table of contents for the worksheet.

2) Designing the content/material of the worksheet

This design focuses on the content of the worksheet material. The content within the worksheet is dynamic fluid material. This material is intended for 11th-grade high school/secondary school students in the first semester. Several sources, such as textbooks, modules, and the internet, are used in the content design. Within the worksheet material, there are also sample problems related to the content. There are several subtopics that will be discussed in the dynamic fluid material. An overview of the material to be covered can

be seen in Worksheet 1 and Worksheet 2, as depicted in Fig. 2.

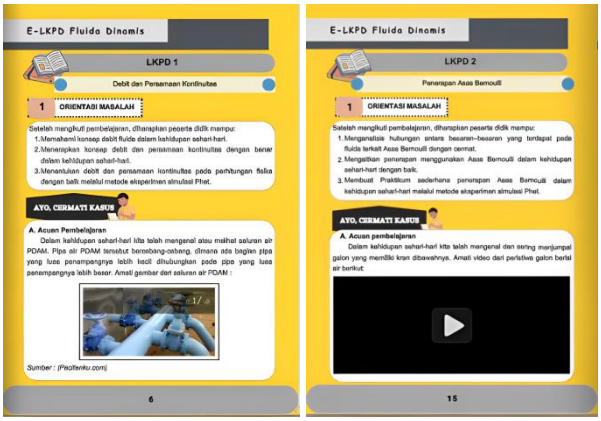

Fig. 2. Subtopics in dynamic fluid.

3) Designing the appearance/layout of the worksheet

After the design of components and content is completed, the development of this worksheet proceeds to the design phase, which includes the selection of colors and background design for the content of the worksheet, choosing a cover that is expected to engage students' interest, and selecting the font style and format for the worksheet. The worksheet's appearance is designed using the Canva application. Once a good visual design is obtained, all the worksheet designs will be combined into a unified application format using Flip Professional. The visual design of the worksheet can be seen in Fig. 3.

Fig. 3. The design of the worksheet's appearance.

4) Designing the instruments/tools

The final stage involves the design of instruments that will be used to validate the worksheet with subject matter experts and media experts. It also includes designing questionnaires for teachers and students to gather their responses and feedback regarding the worksheet that has been created.

C. Development

In this stage, the developed e-student worksheet is validated first before a practical assessment is conducted. The validation instrument for the e-student worksheet is in the form of a questionnaire consisting of four components. The validation results are obtained from the validation test conducted by experts for the Problem-Based Learning (PBL) e-student worksheet. As indicated by V_1 for the score provided by validator 1 and V_2 through V_6, the data analysis results for each component of the validation instrument are as follows.

1) Worksheet for e-student validationon material substance component

The validity test results of the e-student worksheet on the material substance component consist of four indicators, specifically: 1) accuracy; 2) material coverage; 3) currency; and 4) readability. Each of these indicators is represented by four statements. The results of the validity test for the e-student worksheet on the material substance component can be seen in Table 7.

Based on Table 7 there are four indicators, each of which has one to four statements. The meaning of the statements for each indicator is that if each statement is met, the indicator receives a score of 4; if not met, it receives a score below 4.

2) Worksheet for e-student validationon learning design component

The validity test results of the e-student worksheet on the learning design component are obtained through expert assessments. The Learning Design Component consists of nine indicators, specifically: 1) title, 2) SK, 3) KD, 4) indicators, 5) content, 6) sample questions, 7) exercises, 8) authorship, and 9) references. The results of the validity test for the learning design indicators can be seen in Table 8.

Table 7. Results of substance component validity tests

Statement	Validator Score						∑s	V
	v1	v2	v3	v4	v5	v6		
The e-student worksheet presented is in accordance with: a. Scientific principles b. Tabled/tested. c. Factuality (based on facts) d. Logical/rational	3	4	4	3	4	4	16	0.89
The material in the e-student worksheet has been presented in accordance with: a. Material completeness b. Exploration/ development c. Collaboration with other materials/ other subjects. d. Descriptive/imaginative	3	4	4	4	3	3	15	0.83
The e-student worksheet presented already; a. Actuality (in terms of material) b. Up to date (using examples of applications/ implementations based on current real conditions) c. Innovative (coming up with new things)	4	4	3	3	3	3	14	0.78

The e-student worksheet presented uses standard and understandable grammar.	3	4	4	4	4	4	17	0.94
Average								0.86
Category								Valid

Note: V_1−V_6 represents the score given from validator 1 to validator 6 for each statement.

Table 8. Results of learning design component validity tests

Statement	Validator Score						∑s	V
	v1	v2	v3	v4	v5	v6		
The title of the provided e-student worksheet corresponds to the subject matter.	4	4	4	4	3	3	16	0.89
The provided e-student worksheet has an SK that matches the SI.	4	4	4	3	4	4	17	0.94
The KD and SI are matched in the provided e-student worksheet.	4	4	4	3	4	4	17	0.94
The provided e-student worksheet serves as a gauge of the student's proficiency.	3	4	4	4	3	4	16	0.89
The content on the e-student worksheet is in line with the SK-KD.	3	4	4	3	3	4	15	0.83
The provided e-student worksheet includes examples of subjects that match the student's accomplishment indication of competency.	4	3	4	3	4	4	16	0.89
The instruction on the provided e-student worksheet relates to the student's attainment of competency.	4	3	4	3	4	4	16	0.89
The composer's identity is included in the provided e-student worksheet.	4	4	4	4	4	4	18	1.00
There is a reference in the e-student worksheet that provides a list of references.	4	4	4	4	4	3	17	0.94
Average								0.91
Category								Valid

Note: SK (Standar Kompetensi / Standards of Competence), SI (Standar Indikator / Standard Indicator), KD (Kompetensi Dasar / Basic Competence).

Based on Table 8, it can be observed that there is a validity score of 1, which means that this score is the maximum value. This score is assigned to the "authorship" indicator, indicating that the experts have given the highest possible score for this indicator. Therefore, the "authorship" indicator is highly valid as a component of the learning design.

3) Worksheet for e-student validation on visual communication component

The validity test results of the e-student worksheet on the visual communication component are derived from the questionnaire-based validity test, consisting of six indicators. These indicators are: 1) navigation, 2) text, 3) media, 4) color, 5) animation, and 6) layout. The validity results of the e-student worksheet on the visual communication component can be seen in Table 9.

Table 9. Results of visual communication component validity tests

Statement	Validator Score						∑s	V
	v1	v2	v3	v4	v5	v6		
The e-student worksheet presented uses basic navigation and hyperlinks that function well.	4	4	3	4	4	4	17	0.94
The e-student worksheet presented uses legible, well-proportioned letters and good composition.	3	4	3	3	3	4	14	0.78
The e-student worksheet presented uses media in the form of images, sound and video that are appropriate to the material presented.	4	3	3	4	3	4	15	0.83
The e-student worksheet presented has a good color composition and an attractive appearance.	4	4	3	3	4	4	16	0.89
The e-student worksheet presented uses animation that fits the context and does not slow down the slide display.	3	4	3	4	3	3	14	0.78
The e-student worksheet presented has a proportional and attractive design layout.	4	4	3	4	3	4	16	0.89
Average								0.85
Category								Valid

Based on Table 9, there are two indicators with a value of 0.78, which is the minimum score. Additionally, in the visual communication component, there is a value of 0.94, indicating that this indicator is approaching the maximum score.

4) Worksheet for e-student validation on software utility component

The validity test results of the e-student worksheet on the Software Utilization Component are obtained through expert assessments. This component consists of three indicators, specifically: 1) interactivity, 2) supporting software, and 3) originality. The validity results of the e-student worksheet on the software utilization component can be seen in Table 10.

Table 10. Results of software utility component validity tests

Statement	Validator Score						∑s	V
	v1	v2	v3	v4	v5	v6		
The e-student worksheet presented provides feedback from the system to students	4	3	3	3	4	4	15	0.83
The e-student worksheet presented uses supporting software other than the main software	3	4	3	3	4	4	15	0.83
Originality of e-student worksheet.	3	4	3	4	3	3	14	0.78
Average								0.81
Category								Valid

According to Table 10, two indicators have the same value of 0.83, which applies to the "interactivity" and "supporting software" indicators. Even though they have the same value, experts have assigned different scores to each indicator. The identical value is likely due to the final calculation being the result of the aggregate scores provided by the experts.

5) Worksheet for e-student validation on problem based learning component

The validity test results of the e-student worksheet on the problem-based learning component are obtained through

expert assessments. This component consists of 5 indicators, which are: 1) student orientation to the problem; 2) organizing students for learning; 3) guiding individual and group investigations; 4) developing and presenting the work results; and 5) analyzing and evaluating the problem-solving process. The validity results of the e-student worksheet on the problem-based learning component can be seen in Table 11.

Table 11. Results of problem based learning component validity tests

Statement	Validator Score						∑s	V
	v1	v2	v3	v4	v5	v6		
The way the student approached the issue.	4	4	4	4	3	4	17	0.94
Assemble studentss for their studies.	4	4	4	4	3	4	17	0.94
Supervision of both individual and collective research.	4	4	4	4	4	4	18	1.00
Create and showcase the project.	4	4	4	4	4	4	18	1.00
Examine and assess the process of solving problems.	4	4	3	4	4	4	17	0.94
Averge								0.97
Category								Valid

Based on Table 11, it can be observed that the problem-based learning component has received the highest score among the other components. There are two indicators with a score of 1, and the other three indicators are very close to the maximum score. This suggests that the problem-based learning component likely received the maximum score from the experts, indicating its high validity in the e-student worksheet.

The five indicators, including material substance, learning design, visual communication, software utilization, and problem-based learning, all fall into the "valid" category, with Aiken's V values ranging from 0.81 to 0.96. The average Aiken's V analysis result based on these five indicators is 0.88, also categorized as "valid." This indicates that the PBL-based e-student worksheet has a high level of validity and is suitable for use in teaching and learning.

This research has resulted in a product, namely the PBL-based e-student worksheet. Based on the validity test analysis, the e-student worksheet has several advantages compared to other e-student worksheets. The first advantage lies in the learning design component. The e-student worksheet is designed in accordance with the learning design, including the title, basic competencies (SK), core competencies (KD), indicators, content, sample questions, exercises, authorship, and references that use more than three references.

The second advantage can be observed in the visual communication component. The PBL-based e-student worksheet meets the criteria for developing technology-based e-student worksheets. Its visual communication includes a combination of colors that are attractive and provide a proportional view for both text and slide space. Additionally, the e-student worksheet contains video animations and images that actively engage students in learning physics.

The third advantage of the e-student worksheet lies in the software utilization component. The PBL-based e-student worksheet uses various software. The main software used is Flip PDF Professional, which is employed to design the entire e-student worksheet. An additional piece of software is Canva, used to design backgrounds and icons within the e-student worksheet. The use of multiple software programs not only enhances problem-solving skills for students but also trains them in technology proficiency for learning.

Despite its strengths, the development of the PBL-based e-student worksheet does have some limitations. These limitations were identified based on comments and suggestions from the validators. The feedback from validators on the initial product serves as a reference for improving the e-student worksheet.

Improvements made to the e-student worksheet based on the input and suggestions from validators will result in a better teaching resource. A quality teaching resource that has already been validated can then proceed to the next stage, which determines whether the resource is practically effective. The validated e-student worksheet will undergo a trial or practical assessment by teachers and students to determine its practicality and usefulness in an educational context.

D. Implementation

In this stage, the validated e-student worksheet is subjected to a practicality assessment. This assessment is conducted by two physics teachers and XI-grade senior high school students. The instrument used in this stage is a practicality questionnaire consisting of three indicators: the content of the e-student worksheet, the appearance of the e-student worksheet media, and the user-friendliness of the e-student worksheet. The results of the practicality assessment by teachers and students can be described as follows.

1) Assessment practicality by teachers

The practicality test results of the problem-based learning model-based e-student worksheet are analyzed by teachers using an instrument specifically created for the problem-based learning model-based e-student worksheet. The practicality test results for the e-student worksheet based on the problem-based learning model include three assessment aspects. These three assessment aspects are the content of the e-student worksheet, the appearance of the e-student worksheet's media, and the ease of use of the e-student worksheet. Each assessment component contains several indicators, and each indicator within these assessment components is rated on a scale of 1 to 4.

The average of the three components in the teacher's evaluation of the practicality of the analyzed e-student worksheet can be utilized to determine the average value obtained from each component of the student evaluation worksheet based on the problem-based learning model for learning dynamic fluid material physics in the eleventh grade of senior high school, as indicated in Table 12.

Table 12. Practicality result value by teachers

No	Component	Percentage	Category
1	Content of e-student Worksheets based on PBL	93%	Very practical
2	Worksheet media display	97%	Very practical
3	Worksheet convenience	93%	Very practical
	Average	94%	Very practical

Based on Table 12, all three components received scores of over 90%, with a score of 94%, which means they are very close to the maximum score of 100%. The scores of these three components indicate that the practicality test by teachers has found the product to be highly practical and suitable for use as a teaching resource for students.

2) Assessment practicality by students

The students used a e-student worksheet instrument based on this model to assess the practicality of the problem-based learning paradigm. The outcomes of the student's workbook practicality test based on the problem-based learning paradigm consisted of three components: ease of use of e-student worksheets, the media displayed in the e-student worksheet, and its content.

The average of the three components in the evaluation of the worksheet's practicality by student participants, which has been analyzed, can be used to determine the average value obtained from each component of the student evaluation worksheet based on the problem-based learning model for learning dynamic fluid material physics in the eleventh grade of senior high school, as shown in Table 13.

Table 13. Practicality result value by students

No	Component	Percentage	Category
1	Content of e-student worksheets based on PBL	90%	Very practical
2	Worksheet media display	93%	Very practical
3	Worksheet convenience	87%	Very practical
	Average	90%	Very practical

Based on Table 13, one component has a score below 90%, specifically the "ease of use of the e-student worksheet" component with a score of 87%. Although it falls slightly below 90%, a score of 87% is still considered practical, indicating that the product is highly practical and suitable for use as a teaching resource for students.

IV. Discussion

The first achievement in this research pertains to the needs analysis. Teachers hope for the development of more comprehensive and electronically formatted e-student worksheets to motivate students to learn more effectively. Hence, there is a need for the development of e-student worksheet given the crucial role e-student worksheet plays as a teaching and learning tool in the classroom. When teachers encounter issues related to teaching materials, the teaching and learning process may not proceed optimally [29].

By using electronic e-student worksheets, both students and teachers can save time, reduce costs, and minimize paper usage [30], while also adapting to the demands of 21st-century education [31]. E-student worksheet can make learning more engaging and interactive due to the inclusion of images, videos, audios, and hyperlinks [32]. Teachers can conduct demonstrations, and students can engage in practical activities. The development of e-student worksheet that encompasses the specific subject matter aligns with the implementation of the 2013 curriculum. Electronic e-student worksheet is a computer-assisted learning medium that contains graphics, animations, and videos designed to make the learning process more engaging and less monotonous for learners [33]. Electronic e-student worksheet presents instructional content systematically in specific learning units in electronic format, incorporating animations, images, videos, and interactive navigation. Electronic media accessible to students offers varied benefits and characteristics. In terms of its benefits, electronic media can make the learning process more attractive [34].

The results of student selection indicate that students favor problem-based learning-based e-student worksheets. Problem-based learning-based e-student worksheets are expected to enhance students' mastery of the subject matter. Students are interested in learning from topics they already know, such as everyday life issues [35]. The descriptions above suggest that students are highly motivated by enjoyable learning experiences. Students require engaging e-student worksheets, and those incorporating videos can be a preferred choice. This is evident when students exhibit enthusiasm when teachers invite them to watch instructional videos [36].

The second achievement in this research pertains to the validity of the developed product, namely the e-student worksheet with PBL. Validity stems from the word "validity," which refers to authenticity. The validity of a product is a process to test the authenticity of a developed product by obtaining assessments from multiple experts [37]. The assessment components in the validity instrument must be relevant and consistent with the theory used in the preparation of the e-student worksheet [38]. The validity of the PBL-based e-student worksheet is assessed by experts by reviewing five components based on their expertise, namely material substance, instructional design, visual communication appearance, and software utilization [23]. Another assessment component added to the validity is the problem-based learning component.

Material substance adequacy refers to the correctness of the content and symbols, the completeness of the material presentation, the currency of the information, and compliance with the rules of proper and correct Indonesian language writing [39]. The adequacy of visual communication appearance means having clear navigation buttons and attractive animations to create an interactive and engaging learning environment [40]. The adequacy of instructional design means the design of teaching materials that include e-student worksheet components. The adequacy of software utilization means that the e-student worksheet is developed using supporting software that can enhance student interactivity and includes evidence as proof of the originality of the teaching material [41]. The adequacy of problem-based learning assessment means including the syntax of the developed PBL model, which is considered valid and appropriate because it meets the five adequacy

indicators of the e-student worksheet.

The third achievement in this research is the practicality of the PBL-based e-student worksheet. The practicality test is conducted with two teachers and eleventh-grade high school students. The practicality assessment aims to determine the responses of teachers and students regarding the feasibility and practicality of using the PBL-based e-student worksheet. The practicality of the e-student worksheet is assessed based on several indicators, including the content of the e-student worksheet, the appearance of the e-student worksheet media, and the ease of using the e-student worksheet. Practicality needs to be measured to determine the usefulness of the e-student worksheet. Practicality refers to the attractiveness of the e-student worksheet due to its appealing appearance and the inclusion of animations and videos [42]. The efficiency of electronic e-student worksheet is assessed based on its ability to be used at anytime and anywhere, as well as its effective and efficient use of time [43]. Electronic e-student worksheet provides students with the opportunity to learn independently [44]. Electronic student worksheet for solving problems in physics based on problem-based learning are considered practical in an excellent category.

Based on the results obtained from the analysis of needs, validity, and practicality, the product developed can be used to solve problems in physical materials. The PBL-based e-student worksheet can become the primary source of learning in physics. This is in line with the research results that indicate the e-student worksheet has been proven to be valid and practical.

V. Conclusion

Based on the research findings, the following conclusions can be drawn: PBL-based e-student worksheets are valid and suitable teaching materials after undergoing revision and evaluation by experts; The use of PBL-based e-student worksheets is practical for physics learning, as demonstrated by the practicality assessment conducted with two teachers and eleventh-grade high school students.

Based on the results obtained from validity and practicality, the products developed can be used to solve problems in physical matter. Electronic student worksheet are very useful for students to be able to study anywhere and anytime. It can be used continuously and can be applied to daily life.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

Monadia P. Nenggala conducted this study, analyzed the data, collected the data, wrote the paper; Monadia P. Nenggala and Pakhrur Razi had approved the final version. Hidayati and Silvi Yulia Sari provide research guidance, review and provide suggestions in product development. The final manuscript has been written with the participation of all authors.

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