PILLAR OF PHYSICS EDUCATION
Vol. 19 (4), 2026, pp. 377–390
ISSN (Print) : 2337-9618
ISSN (Online) : 2684-8880

DESIGN OF AN ELECTRONIC STUDENT WORKSHEET ON STATIC FLUIDS BASED ON INQUIRY LEARNING, SUPPORTED BY SIMPLE EXPERIMENTS AND INTEGRATING LOCAL WISDOM TO FACILITATE STUDENTS' CRITICAL THINKING SKILLS

Suci Ramatillah[1] , Selma Riyasni[1*] , Asrizal[1] , Dea Stivani Suherman[1]

[1]*Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar, Padang 25131, Indonesia*
Corresponding author. Email:selma.r@fmipa.unp.ac.id

ABSTRACT

The critical thinking skills of 11th-grade students at SMAN 1 Sutera in physics class fall into the low category (29.98%). The worksheets used do not include independent inquiry activities, and experimental activities are limited due to inadequate facilities. This study aims to produce a valid and practical prototype of an inquiry-based electronic student worksheet on Static Fluids, supported by simple experiments and integrated with local wisdom, to facilitate critical thinking skills. This study employed Plomp's Educational Design Research (EDR) model, limited to the preliminary research and prototyping phases; the assessment phase and effectiveness testing were not conducted. The electronic student worksheet was designed to follow the five phases of inquiry (orientation, conceptualization, investigation, conclusion, and discussion) using simple experiments with readily available materials and phenomena from the local wisdom of the South Coast as the context for investigation. Validity was assessed by five physics lecturers and analyzed using Aiken's V index. Practicality was assessed via a questionnaire completed by two physics teachers and nine students (in a small group), following one-on-one testing with three students, and then analyzed as a percentage. The average Aiken's V score was 0.93 (valid). The practicality percentage was 93.82% based on teacher responses and 90.23% based on student responses, both of which were categorized as very high. Thus, the electronic student worksheet prototype was deemed valid and highly practical in a limited test with a small sample. Its effectiveness in fostering critical thinking skills has not yet been tested and needs to be investigated during the assessment phase.

Keywords: electronic student worksheet; Static Fluids; Inquiry Learning; simple experiments; local wisdom.

Pillar of Physics Education is licensed under a Creative Commons Attribution ShareAlike 4.0 International License.

I. INTRODUCTION

The development of education in the 21st century is marked by advances in digital technology and changing societal needs that require students to possess skills relevant to the times. These changes demand that the education sector prepare students who not only master the subject matter but are also able to adapt and solve problems in their environment. Learning is no longer solely focused on the acquisition of knowledge but also on the development of the 6C skills: *critical thinking, creativity, collaboration, communication, citizenship, and character* [1] . In line with this, the Merdeka Curriculum emphasizes student-centered, contextual learning that fosters comprehensive thinking skills. Learning must be designed to actively engage students and enable them to connect the material to their daily lives.

Physics, as a branch of the natural sciences, is closely tied to natural phenomena and the scientific inquiry process. Learning physics requires students not only to understand concepts and formulas, but also to observe, analyze, evaluate, and draw conclusions based on evidence [2] . Critical thinking skills are essential for students to process information and draw logical conclusions based on relevant evidence [3][4] .

In reality, these ideal conditions have not yet been achieved in the classroom. A preliminary study conducted through interviews, classroom observations, and document analysis at SMAN 1 Sutera showed that physics

instruction has engaged students, for example, through group discussions, question-and-answer sessions, and presentations. This teaching is already student-centered. However, this engagement has not yet taken the form of structured *inquiry*-based *learning*—that is, a cycle in which students formulate questions and hypotheses, collect and analyze data, and draw conclusions based on evidence. Experimental activities also remain limited due to inadequate facilities. A student-centered approach does not automatically foster critical thinking skills. This is reflected in the results of the initial critical thinking skills test for 11th-grade students in Phase F at SMAN 1 Sutera. The average score was only 29.98% (low category), with the lowest scores on the *"bases for decision"* and *"inference"* indicators. These results indicate that students have not yet mastered the critical thinking indicators and that instruction has not optimally facilitated their development. Another issue was identified in the instructional materials used. The worksheets available are generally in printed form and contain only summaries of the material and practice problems. These worksheets lack interactive features and do not include activities that guide students to conduct investigations and analyze their observations independently. Furthermore, inquiry-based learning has not been fully implemented, while experimental activities remain limited due to a lack of facilities.

These conditions highlight the need to develop instructional materials in the form of electronic student worksheet that can facilitate students in conducting active and independent investigations, such as through electronic student worksheet based on *inquiry learning.* This model positions students as the subjects of learning [5] In this study, inquiry-based learning refers to the five phases outlined by Pedaste et al. [6] namely orientation, conceptualization (formulating questions and hypotheses), investigation (exploration/experimentation and data interpretation), conclusion, and discussion (communication and reflection). This framework is consistently applied in the design, validation, and discussion of the product. The electronic student worksheet can present learning activities interactively through text, images, videos, and questions, and can be accessed using electronic devices [7] . To address limitations in facilities, inquiry activities can be designed using simple experiments with easily obtainable tools and materials. Furthermore, the integration of local wisdom helps students connect physics concepts to their environment and daily experiences, making learning more meaningful.

In this study, local wisdom is defined as the knowledge, values, and practices that have developed within a community through its interactions with the environment and have been passed down from one generation to the next [8] . The scope is limited to the activities and phenomena of the Southern Coastal community in West Sumatra that involve the concept of static fluids. Local wisdom is used as the context for inquiry: students observe these phenomena, ask questions, and analyze them using the concept of static fluids, rather than merely using them as illustrations. The integration of local wisdom connects physics concepts to phenomena and environments that are close to students' lives, making learning more contextual and meaningful [9][10] . Relevant cultural contexts have also been reported to bridge students' everyday experiences with academic knowledge and to enhance motivation and creativity in learning [11] . Local phenomena can serve as objects for observation and analysis.

A number of studies have developed instructional materials based on inquiry and local wisdom. electronic student worksheet, or guided inquiry instructional materials, have been reported to support critical thinking skills [4] . The study [10] reports that guided inquiry instructional materials are appropriate and effective, but do not utilize simple experiments based on local contexts. The study *at* [12] also shows that *guided inquiry-based* electronic student worksheet have high validity and practicality and can support critical thinking skills. However, this study has not fully integrated *inquiry learning*, simple experiments, and local wisdom into a single electronic student worksheet, particularly in the topic of static fluids. Physics teaching materials based on local wisdom have also been developed [8] , including those designed to foster critical thinking. While these approaches all have the potential to enhance critical thinking skills, there has been little research combining inquiry-based learning with simple experiments grounded in local contexts.

Based on the author's literature review, no interactive electronic student worksheet on static fluids has yet been found that integrates all four components simultaneously: a comprehensive inquiry phase; simple experiments as a solution to laboratory limitations; local wisdom phenomena of the Southern Coast as the context for investigation; and activities designed based on a diagnosis of students' critical thinking weaknesses, particularly regarding the "bases for decision" and "inference" indicators. The novelty of this study lies in the integration of these four components into a single interactive electronic student worksheet on static fluids.

The purpose of this study is to develop a prototype of an inquiry-based electronic student worksheet on static fluids, supported by simple experiments and incorporating the local wisdom of the South Coast region. The prototype was designed to facilitate critical thinking skills among 11th-grade students. In addition to producing the prototype, this study also tested its validity through evaluations by five experts and assessed its practicality based on feedback from two teachers and nine students. This study was limited to the preliminary research and prototype stages in Plomp's development model.

II. METHOD

a. Research Type and Procedures

This study employs Plomp's *Educational Design Research* (EDR) model [13] . This model consists of three phases: preliminary research, the prototyping phase, and the assessment phase. The scope of this study covers the first two phases. Preliminary research was conducted to identify needs and serve as the basis for product design. The prototyping phase involved formative evaluation through small-group testing to produce a valid and practical Inquiry Learning-based electronic student worksheet on Static Fluids, supported by simple experiments and integrated with local wisdom, for use in physics instruction at SMAN 1 Sutera. The assessment phase (effectiveness test) was not conducted. Thus, this study only assessed the validity and practicality of the prototype, not its effectiveness in improving critical thinking skills.

The study was conducted at SMAN 1 Sutera, which was selected based on specific considerations: preliminary findings indicated the presence of physics learning issues relevant to the research focus, and the school granted permission and access to conduct the study. The preliminary research phase aimed to identify learning needs and issues through a needs analysis, an analysis of student characteristics, and a literature review. The needs analysis was conducted through interviews with two 11th-grade physics teachers at SMAN 1 Sutera to gather information regarding learning conditions, the use of learning resources, and the need for electronic student worksheet. The analysis of student characteristics was conducted on 32 11th-grade students in Phase F1—that is, all students in one class—to determine their abilities, level of engagement, and use of technology in learning. Furthermore, a literature review was conducted on static fluid mechanics, Inquiry Learning, simple experiments, local wisdom, and critical thinking skills as the foundation for designing the product.

The prototyping phase was carried out through the design of a prototype and step-by-step formative evaluation. The prototype design resulted in a preliminary design of the Inquiry-Based electronic student worksheet on Static Fluids, supported by simple experiments and integrated with local wisdom. Formative evaluation included self-evaluation, expert review, one-on-one evaluation, and small-group evaluation. The researcher conducted the self-evaluation to assess the appropriateness of the content, format, inquiry phases, simple experiments, and local wisdom. The expert review was conducted by five physics lecturers from the Department of Physics, FMIPA UNP, selected based on their expertise and experience to assess the substance of the material, visual communication design, electronic student worksheet components, software utilization, the application of the inquiry learning model in the electronic student worksheet, critical thinking skills, and the incorporation of local wisdom into the electronic student worksheet. The one-to-one evaluation involved three students with high, moderate, and low academic ability, as determined by test scores. The small-group evaluation involved two physics teachers and nine students (three with high ability, three with moderate ability, and three with low ability, based on the grouping criteria) to assess the practicality of the product. The results of each evaluation were used as the basis for revisions until a valid and practical electronic student worksheet prototype was obtained.

In accordance with the stages of formative evaluation in Plomp's model [13], the evaluation was conducted sequentially: self-evaluation, expert review, one-on-one, and small group. The results of each stage were used to revise the product before the next stage. The students in the one-on-one and small group sessions were different, as the small group tested a version of the electronic student worksheet that had already been revised based on feedback from the one-on-one sessions. Participants in the formative evaluation were selected from the target users, namely 11th-grade students. These students came from other classes at the same grade level and did not include the 32 students from the preliminary study. All five validators were from the same department; this is discussed as a limitation of the study.

b. Research Instruments and Data Analysis Techniques

The instruments were used in two phases: the preliminary study and the prototype phase. In the preliminary study, the instruments consisted of a teacher interview guide designed to explore learning conditions, the use of media and instructional models, needs for teaching materials, and challenges in teaching static fluids. The student questionnaire explored learning experiences, difficulties, and the need for more interactive teaching materials. The context analysis sheet evaluated the worksheets used by teachers. The pretest, consisting of essay questions based on critical thinking skill indicators, was used to assess students' initial abilities. In the prototype phase, the instruments included a self- evaluation sheet to check the completeness and errors in the product; a validation sheet for five faculty members; a one-on-one questionnaire to assess ease of use, clarity of content, and comprehensibility of instructions; and a small-group practicality questionnaire for two teachers and nine students to assess ease of use and readability, presentation, effectiveness, and benefits.

The content validity of the interview guidelines, questionnaire, pretest questions, validation sheet, and practicality questionnaire was reviewed by the supervising instructor. The validation sheet and practicality questionnaire were also reviewed by an evaluation expert, after which all instruments were revised based on that feedback. The reliability of the instruments was not statistically tested due to time constraints. This constitutes a limitation of the study. The pretest results were used only to describe the initial needs in the preliminary study, not to draw conclusions about the product's effectiveness.

The pretest consisted of essay questions designed based on Ennis's indicators of critical thinking skills. Each item was scored using a 0–4 rubric, with descriptions of achievement levels for each score that reflected the completeness and accuracy of the students' answers. Each student's score is totaled, and the achievement percentage is calculated by dividing the score earned by the maximum score and then multiplying by 100%. Achievement percentages are calculated per indicator and overall, allowing for the identification of the weakest and strongest indicators. The results are interpreted using the criteria [14] . The average achievement of all students was 29.98%, placing them in the low category.

A contextual analysis was conducted on the worksheets used by teachers at SMAN 1 Sutera to determine the extent to which these worksheets support learning needs. The analysis utilized an analysis sheet containing a number of indicators. Each indicator was scored on a scale of 1–5; the context percentage was then calculated by dividing the achieved score by the maximum score and multiplying by 100%. The score of 52.8% falls into the "low" category, meaning that the worksheets used do not yet fully support students' learning needs, primarily because they do not include independent inquiry activities and are not interactive. This finding serves as one of the grounds for the need to electronic student worksheet.

Critical thinking skills in this study refer to Ennis's framework [15] . This framework consists of five indicators: *basic clarification* (providing a simple explanation), *bases for decision* (building basic skills), *inference* (drawing conclusions), *advanced clarification* (providing further explanation), and *strategy and tactics* (developing strategies and tactics). This framework was used in the pretest as the basis for developing test items and analyzing achievement per indicator; in the design of electronic student worksheet activities to ensure that inquiry-based activities address indicators where students are still weak; and in the validation phase as a reference for assessing critical thinking skills. The use of a single, consistent framework is expected to ensure that identified student weaknesses, activity designs, and expert assessments can be tracked consistently.

Product validity data were obtained through evaluations by five expert validators using a 1–5 Likert-scale validation sheet. To determine the level of product validity for each aspect evaluated, the evaluation data were analyzed using *Aiken's V* index. This index was chosen because it can convert scores from multiple validators into a single value that reflects the level of validity for each item as well as for the aspect as a whole. *Aiken's V* is calculated using the following formula:

$$V = \frac{\sum s}{[n(c-1)]} \quad \text{.....(1)}$$

$$S = r - l_0 \quad \text{.....(2)}$$

Notes: V = Aiken's validity index; ΣS = sum of S values from all validators for a single item or aspect; r = score assigned by a validator; l_0 = lowest score (1); c = highest score (5); n = number of validators (5).

The obtained Aiken's V value is then interpreted based on the product validity criteria as presented in Table 1. The product is deemed valid if the obtained Aiken's V value falls within the "valid" category.

Table 1. Validity criteria based on Aiken's V index

Interval	Category
$\boldsymbol{V < 0,8}$	Invalid
$\boldsymbol{V \geq 0,8}$	Valid

(Source:[16])

The V threshold of ≥ 0.8 is based on Aiken [16] , which provides critical values for the V index based on the number of raters and the number of score categories. These critical values are intended to distinguish inter-rater agreement from agreement that occurs by chance. In this study, five validators and five score categories were used (scale 1–5), so a value of 0.8 was used as the minimum threshold for an item or aspect to be deemed valid. This threshold is also used in research on the development of instructional materials that employ five validators.

However, the small number of validators means that the validation results can only be viewed as preliminary evidence of the product's content feasibility and cannot yet be generalized.

In addition to quantitative data, this study collected qualitative data in the form of validators' comments and suggestions on the validation sheets, as well as students' responses to the one-on-one and small-group questionnaires. The comments and suggestions were reviewed in their entirety; those relevant to product improvements were then selected and grouped based on the assessed aspects, namely content substance, visual communication design, instructions and electronic student worksheet components, software utilization, the application of inquiry-based learning, critical thinking skills, and local wisdom. In the conclusion-drawing stage, each piece of feedback was categorized as requiring revision or not requiring revision; feedback requiring revision was then translated into corrective actions for the electronic student worksheet. The results of this qualitative analysis were used in conjunction with the quantitative results to refine the prototype before proceeding to the next evaluation stage.

In addition to validity, the product's feasibility is also determined based on practicality. The practicality analysis was conducted based on the results of a questionnaire administered to teachers and students during the *one-on-one* and *small-group* pilot testing phases. These questionnaires were used to determine the extent to which the electronic student worksheet was easy to use, understandable, and helpful to students in their learning activities. The data obtained from the questionnaires were then calculated as percentages to illustrate the overall level of the product's practicality and subsequently interpreted based on the practicality criteria in Table 2.

$$Practicality\ percentage(\%) = \frac{obtained\ score}{maximum\ score} \times 100\% \quad \text{.....(3)}$$

where the total score is the sum of the scores given by respondents (teachers or students) on all items of the practicality questionnaire, and the maximum score is the highest possible total score on all those items. The percentage is calculated separately for teacher responses and student responses. The resulting practicality percentages are then interpreted based on the criteria in Table 2.

Table 2. Practicality Criteria

Total Score Range (%)	Category
81–100	Very High
61–80	High
41–60	Moderate
21–40	Low
0–20	Very Low

(Source: [14])

This study involved 11th-grade students, physics teachers, and university lecturers as participants. Prior to data collection, the researcher obtained research permission from the school/principal of SMAN 1 Sutera. The researcher explained the purpose and procedures of the study to the participants and obtained consent from the students, teachers, and validators. Participation was voluntary, and participants could withdraw at any time without consequences. The collected data was kept confidential, reported without identifying the participants, and used solely for the purposes of this study.

III. RESULTS AND DISCUSSION

Results

a. Prelimin*ary* Research

This study resulted in *the development of* an *inquiry-based* electronic student worksheet on Static Fluids, supported by simple experiments and integrated with local wisdom, to facilitate students' critical thinking skills. *Preliminary research* was conducted as an initial step to identify learning needs that would serve as the basis *for* developing *an inquiry-based* electronic student worksheet on Static Fluids*,* supported by simple experiments and integrated with local wisdom, to facilitate students' critical thinking skills. Activities at this stage included needs analysis, analysis of student characteristics, a literature review, and an analysis of the of critical thinking skills through a pretest. The results of the preliminary research are reported here as they form the basis for the prototype

design, in accordance with the scope of the study, which encompasses both the preliminary research and the prototype phase.

The needs analysis was conducted through interviews with physics teachers, the distribution of questionnaires to students, and an analysis of the context of the worksheets used at the school. The interview results showed that the worksheets used were printed versions that contained only summaries of the material and practice problems; experimental activities were still limited due to inadequate laboratory facilities; and the implementation of inquiry-based learning had not yet been fully implemented. The questionnaire results showed that all 32 students reported that experimental activities were still limited; students preferred learning supported by digital devices; and all students had access to mobile devices and the internet. An analysis of the characteristics of the 32 students in Grade 11 Phase F1 revealed that students' academic abilities varied—ranging from high, moderate, to low—and that students already had access to and were accustomed to using digital technology to search for materials or complete assignments via mobile devices. These characteristics served as the basis for determining a web-based digital platform accessible via mobile devices and for establishing varying levels of difficulty in the electronic student worksheet activities. Furthermore, the results of the contextual analysis of the worksheets used by teachers showed a percentage of 52.8%. This finding indicates that these worksheets do not yet fully support students' learning needs, as they are in print format, lack interactivity, and do not guide students to conduct independent investigations. The analysis of critical thinking skills was conducted through a pretest administered to 32 students in Grade XI Phase F1. The average critical thinking skills score was 29.98% (low category). The scores for each Ennis indicator are presented in Table 3 and Figure 1.

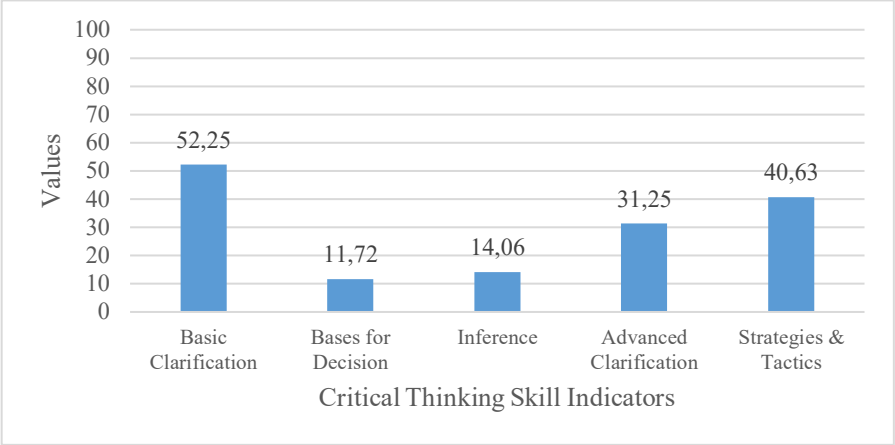


Figure 1. Critical Thinking Skills Test Results

Table 3. Pretest Results for Critical Thinking Skills by Indicator (n = 32)

Critical Thinking Indicators	Score (%)	Category
Basic clarification	52.25	Satisfactory
Strategy and tactics	40.63	Satisfactory
Advanced clarification	31.25	Low
Inference	14.06	Very low
Bases for decision	11.72	Very low
Average	29.98	Low

Based on Table 3 and Figure 1, the highest achievement was found in the "basic clarification" indicator (52.25%, "adequate" category), followed by "strategy and tactics" (40.63%), "advanced clarification" (31.25%), "inference" (14.06%), and "bases for decision" (11.72%) as the lowest. Students' critical thinking skills were classified as low across most indicators, particularly "bases for decision" and "inference." This indicates that students still struggle to use appropriate grounds for making decisions and to draw conclusions based on data. These results indicate that students' critical thinking skills need to be fostered through instructional materials in the form of electronic student worksheet that engage students in activities such as identifying problems, gathering and analyzing information, drawing conclusions, and determining problem-solving strategies. This situation underscores the need to develop electronic student worksheet capable of providing a more focused learning experience and training students' critical thinking skills.

A literature review was conducted to establish a foundation for the development of electronic student worksheet by examining Inquiry Learning, electronic student worksheet, static fluid materials, simple experiments, local wisdom, and critical thinking skills. The review of static fluid materials covered concepts and their

applications in daily life that can be used as a context for inquiry. The review of Inquiry Learning and critical thinking skills was used to determine the stages of activities that can train students' critical thinking processes. The review of electronic student worksheet and simple experiments served as the basis for designing the presentation of material and inquiry activities that can be carried out with simple equipment. Meanwhile, the review of local wisdom was used to relate the concepts of static fluids to phenomena familiar to students' daily lives. Based on these studies, the electronic student worksheet was developed by integrating Inquiry Learning, simple experiments, and local wisdom to foster critical thinking skills.

b. Development*/Prototyping Phase*

The designed products then went through the stages *of self-evaluation, expert review, one-on-one review,* and *small-group review. Self-evaluation* was conducted prior to the expert review. Developers checked the completeness of the electronic student worksheet, corrected errors, and supplemented missing sections using assessment instruments. The findings are: (1) the structure of the electronic student worksheet already includes the components of a worksheet, namely the title, instructions for use, competencies to be achieved, supporting information, learning activities and exercises, assessment, author, and references; (2) learning activities have been organized according to the five stages *of inquiry-based learning*; (3) simple experimental tools and materials are easily obtainable, and the activity steps are clearly presented; (4) local wisdom phenomena related to the concept of Static Fluids need to be adjusted; (5) language, spelling, and punctuation errors in the initial version have been corrected; and (6) font size and layout have been adjusted for better readability. The revised version was then submitted for expert validation.

The *expert review* process was conducted to gather feedback on the substance of the material, the visual presentation, the components of the electronic student worksheet, the use of software, the application *of inquiry-based learning*, critical thinking skills, and the integration of local wisdom. This feedback consists of comments and suggestions for improvement written by the validators on the validation sheet. All suggestions were reviewed by the researchers and used to revise the parts of the electronic student worksheet that still had shortcomings.

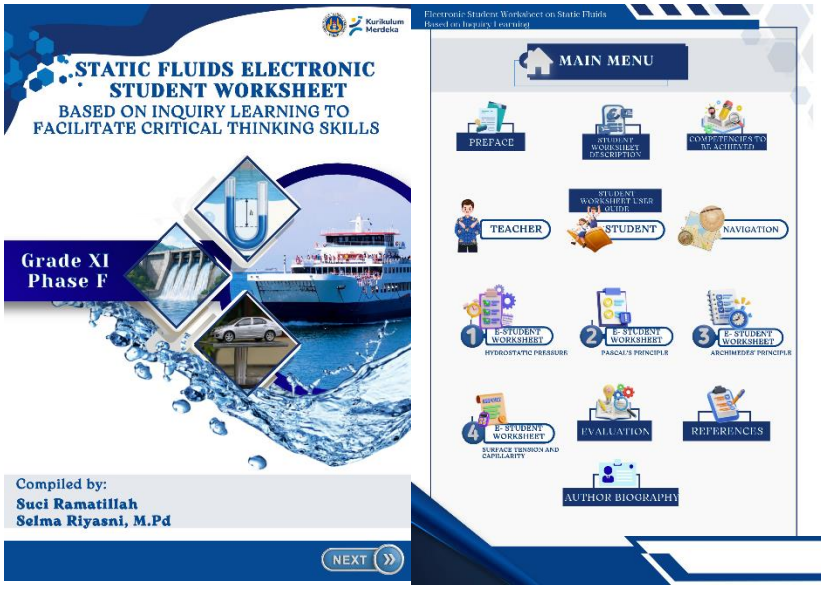
The prototype design resulted in an electronic student worksheet containing material on static fluids, presented through five stages *of inquiry-based learning*: orientation, conceptualization, investigation, conclusion, and discussion and reflection. Each stage is designed to engage students in observing phenomena, formulating questions, collecting and analyzing data through simple experiments, and drawing conclusions based on the results of their investigations. Additionally, the electronic student worksheet includes questions and activities aimed at developing critical thinking skills. The concept of static fluids is also linked to phenomena and activities related to the local wisdom of the South Coast, so that students can connect physics concepts to their environment and daily lives. In the final section, the electronic student worksheet includes an assessment consisting of critical thinking questions used to measure the extent to which students understand the concept of static fluids.

Table 4. Mapping of concepts, local wisdom, simple experiments, inquiry phases, and indicators of critical thinking

Concept of static fluids	Local Knowledge of the South Coast	Simple Experiments	*Inquiry* Phases	Critical Thinking Indicators
Hydrostatic Pressure	The Sawah Laweh Dam in South Pesisir Regency	Building a simple Hartl apparatus using a plastic bottle and a hose to investigate the relationship between the depth of a liquid and hydrostatic pressure	Orientation, conceptualization, investigation, conclusion, discussion, and reflection	*Basic clarification*, *advanced clarification*, *bases for decision-making*, *inference*, *strategy, and tactics*
Pascal's Principle	Hydraulic press for processing coconut oil/coconut milk in South Pesisir and the application of hydraulic equipment	Building a miniature hydraulic machine using two syringes with different cross-sectional areas, a hose, water, and a load	Orientation, conceptualization, investigation, conclusion, discussion, and reflection	*Basic clarification*, *advanced clarification*, *bases for decision-making*, *inference*, *strategy, and tactics*
Archimedes' Principle	Bagan/biduak, a traditional boat used by coastal communities in the South Coast region for fishing	Investigating the relationship between the mass of the load, the volume of the submerged object, the volume of water displaced, and buoyant force using a balance, a spring, a measuring cup, water, and a load	Orientation, conceptualization, investigation, conclusion, discussion, and reflection	*Basic clarification*, *advanced clarification*, *bases for decision-making*, *inference*, *strategy, and tactics*

Concept of static fluids	Local Knowledge of the South Coast	Simple Experiments	*Inquiry* Phases	Critical Thinking Indicators
Surface tension and capillarity	Togok lamp	Observing the rise in water level in straws of different diameters to investigate the relationship between straw diameter and the height of the water rise	Orientation, conceptualization, investigation, conclusion, discussion, and reflection	*Basic clarification*, *advanced clarification*, *bases for decision-making*, *inference*, *strategy, and tactics*

The introduction begins with a cover page that includes the title, identification information, target audience, logo, and characteristics *of the inquiry*-based electronic student worksheet. Next, a main menu is provided to make it easier for users to access each section of the electronic student worksheet. The electronic student worksheet description explains the product's characteristics, the *inquiry-based learning* framework, and indicators of creative thinking skills. The user guide contains instructions for teachers and students, as well as explanations of the navigation buttons' functions. This section is supplemented with the competencies to be achieved, in the form of Learning Outcomes and Learning Objectives. The electronic student worksheet interface is shown in Figure 2.



(a) (b)

Figure 2. Interface: (a) Cover and (b) Menu

The activity pages contain supporting information and learning activities organized according to the *inquiry learning* framework, which consists of five stages: orientation, conceptualization, investigation, conclusion, and discussion and reflection. During the orientation stage, students observe static fluid phenomena relevant to their daily lives, including local wisdom phenomena from the Southern Coast. Presenting these contextual phenomena helps students connect physics concepts to everyday life. Next, during the conceptualization stage, students formulate questions and hypotheses based on the observed phenomena. Students then conduct investigations through simple experiments using readily available tools and materials, and subsequently collect and analyze the data from their observations. Based on this data, students draw conclusions and communicate them during the discussion and reflection stage, thereby developing their critical thinking skills. The electronic student worksheet concludes with an evaluation section, references, and the authors' information. The evaluation section includes questions to assess students' understanding of the material and competencies they have learned. The references section lists the sources used in developing the electronic student worksheet, while the authors' information section provides details about the authors and supervisors. The activity page is shown in Figure 3.

Electronic student worksheet was developed on the Topworksheets platform, a web service that transforms worksheets into interactive worksheets that students can complete directly. This platform was chosen because all students have devices and internet access, as well as for other reasons—for example, it requires no installation, is available for free, and supports answer entry. Students access electronic student worksheet via the electronic student worksheet URL link. The type of answer entry used is short-answer. A limitation of this platform is that it requires an internet connection, so students without internet access cannot complete the worksheets. Additionally,

the display and navigation depend on the browser and screen size, leading students to complain about navigation during the one-to-one trial.



Figure 3. Display of the Learning Activity

During the validation phase, the developed electronic student worksheet was evaluated by five expert validators to determine the product's suitability and feasibility before it was used in pilot testing. The evaluation focused on several aspects related to content substance, visual communication design, electronic student worksheet components, *software* utilization, the application of *inquiry-based learning*, critical thinking skills, and the integration of local wisdom. The results of the validators' assessment were then used as the basis for determining the suitability of the electronic student worksheet and as a basis for making improvements to the product before proceeding to the pilot testing phase.

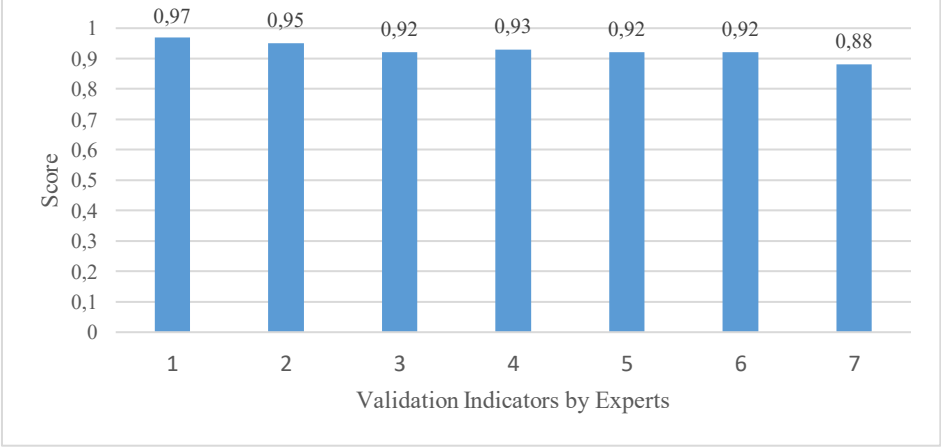


Figure 4. Validation Results by Experts

The validation results from five validators are presented in Figure 4 and Table 4. The overall average Aiken's V was 0.93 (valid), and all aspects had a $V \geq 0.88$, thus meeting the 0.80 threshold. The content substance aspect received the highest score (0.97), while the use of local wisdom aspect received the lowest score (0.88), although it was still categorized as valid. These scores indicate that, according to the validators, the inquiry phase and critical thinking activities were designed in accordance with the framework used. Expert validation assesses the suitability of the design; therefore, these results do not yet indicate that the electronic student worksheet is effective in guiding students to formulate problems, develop hypotheses, and draw conclusions based on evidence. Such effectiveness can only be determined after testing during the assessment phase

Table 5. Expert validation results by aspect (n = 5 validators)

No.	Aspect	Aiken's V	Category
1	Content	0.97	Valid
2	Visual Communication Design	0.95	Valid
3	Electronic Student Worksheet Components	0.92	Valid
4	*Software* Utilization	0.93	Valid
5	Use of *inquiry-based learning*	0.92	Valid
6	Critical thinking skills	0.92	Valid
7	Use of Local Wisdom	0.88	Valid
	Average	0.93	Valid

A practicality test of *the Inquiry Learning-based* electronic student worksheet on Static Fluids—which incorporates simple experiments and integrates local wisdom to foster students' critical thinking skills—was conducted in a *one-on-one* setting. The *one-on-one* test aimed to assess the electronic student worksheet comprehensibility, ease of use, presentation, effectiveness, and benefits based on students' direct experiences. This test involved three students with high, moderate, and low ability levels. The students' feedback was used to identify which parts of the electronic student worksheet still needed improvement. Improvements were made based on the students' feedback to make the electronic student worksheet easier to understand and use before proceeding to the small-group testing phase. The results of the *one-on-one* test are shown in the following figure 5.

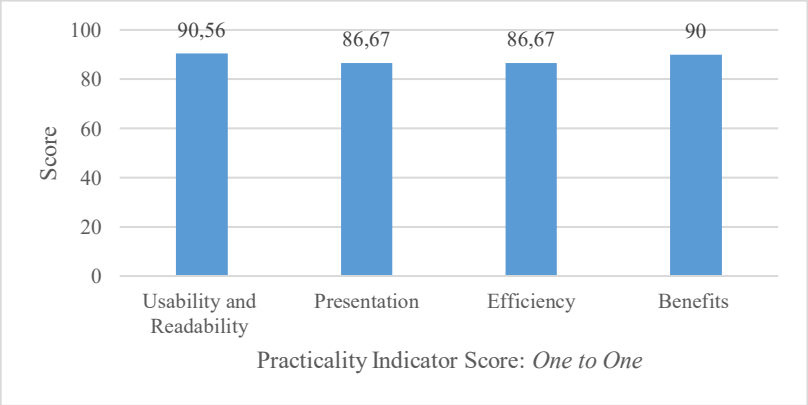


Figure 5. Results of the *One-to-One* Analysis

Based on the results of the *one-to-one* testing, the researcher revised several sections of the electronic student worksheet in accordance with the feedback and difficulties identified by the students. Revisions were made to sections deemed unclear, such as the work instructions, experimental activity instructions, font size, and navigation on *Topworksheets*. Several sentences in the questions and activity steps were also revised to make them simpler and easier for students to understand. These revisions resulted in an electronic student worksheet that is clearer, easier to use, and better suited to the students' characteristics, allowing the project to proceed to the small-group testing phase.

A practicality test of the Inquiry Learning-based electronic student worksheet on Static Fluids, supported by simple experiments integrated with local wisdom, was conducted to determine the practicality of the developed product. The practicality test was carried out in a small-group pilot phase involving 2 physics teachers and 9 students as users of the electronic student worksheet. The evaluation was conducted after the teachers and students used the electronic student worksheet in learning activities on the topic of Static Fluids. The practicality assessment instruments for teachers and students consisted of four evaluation components: ease of use, presentation, effectiveness, and benefits of the electronic student worksheet. As a result, the electronic student worksheet received ratings from both teachers and students in the "very practical" category for all four components.

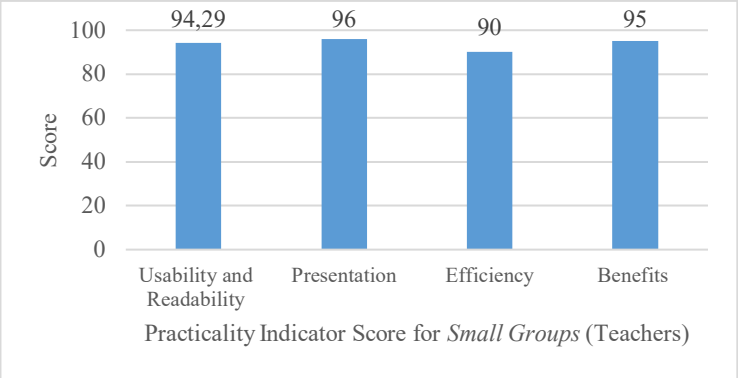


Figure 6. Practicality Results for *the Small Group of* Teachers

The results of the electronic student worksheet practicality assessment by teachers showed an average score of 93.82%, falling into the "very practical" category. These results indicate that *the Inquiry Learning-based* electronic student worksheet on Static Fluids, supported by simple experiments and integrated with local wisdom, can be easily used in the learning process. Complete data on the practicality assessment results by teachers. Next, the electronic student worksheet practicality test was conducted with students in *small groups* to determine the level of practicality of the electronic student worksheet based on student responses.

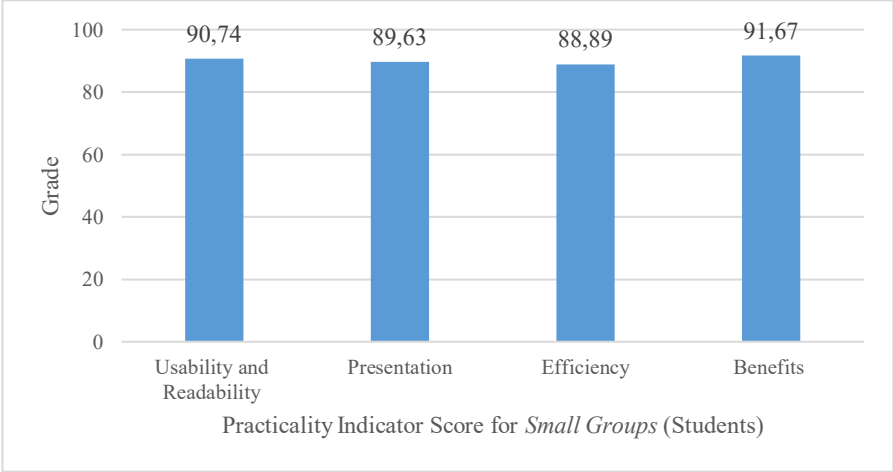


Figure 7. *Small-Group* Practicality Results from Students

Based on Figure 7, the average scores for each component of the practicality of the Inquiry Learning-based electronic student worksheet on Static Fluids—which incorporates simple experiments and local wisdom—as assessed by students can be seen. The average scores obtained in the electronic student worksheet practicality test fall into the "very practical" category. This means that students assessed the electronic student worksheet as meeting their learning needs. These results indicate that the developed electronic student worksheet possesses an excellent level of practicality and can be used by students in their study of Static Fluids. Results of the electronic student worksheet practicality analysis based on student assessments.

Discussion

Preliminary research findings indicate a gap between physics learning needs and conditions in schools. A contextual analysis of the worksheets used by teachers revealed that only 52.8% of them met the requirements, indicating that these worksheets do not fully support students' learning needs. This situation aligns with the characteristics of printed worksheets, which typically contain only summaries of the material and practice problems without inquiry-based activities. At the same time, pretest results showed that students' average critical thinking skills fell into the low category (2998%), even though these skills are necessary for students to process information and draw conclusions based on evidence and are essential competencies in physics learning [3]. Further critical thinking skills test results showed that the highest achievement was found in *the "basic clarification*" indicator, while the lowest achievement was found in *the "bases for decision"* and *"inference"* indicators. The high achievement in "basic clarification" is due to the fact that this indicator represents the most fundamental ability: focusing on and answering clarification questions by utilizing the knowledge students already possess. This finding is supported by research [17], which shows that the indicator "providing a simple

explanation" is the highest achievement in students' critical thinking profiles in physics lessons, as this indicator is considered the easiest because it is directly related to phenomena students encounter in their daily lives.

The validation results from five validators across seven assessment components, as shown in Figure 4, indicate that all components met the minimum threshold for the "valid" category; therefore, the electronic student worksheet was deemed valid overall. These results must be interpreted with caution. The Aiken's V values were high and consistent across the five validators on a 1–5 scale. High scores may also reflect a tendency for evaluators to be lenient, and since all validators came from a single department, the perspectives of practicing teachers and media experts were not represented. Furthermore, the validation assessed the appropriateness of the design. The content substance component received the highest score, which was due to the development of the material being grounded in literature reviews and learning outcomes. This finding is also supported by the study [18], which indicates that high validity scores in the content aspect are attributed to scientifically accurate learning indicators and concepts. Regarding visual communication, the assessment covered indicators such as navigation, fonts, media, colors, and layout. The validation results showed that the electronic student worksheet features clear navigation and instructions, easily readable fonts, as well as appropriately proportioned images and layouts to present fluid phenomena and simple experimental steps. These findings are supported by a study at [19], which indicates that these high ratings are supported by the presentation of the student worksheet with legible fonts, harmonious colors, and an organized layout, making it easier for students to follow the activities and for teachers to guide the learning process.

Regarding the components of the electronic student worksheet, the assessment covered the following indicators: title, learning instructions, competencies, supporting information, steps, assessment, author, and references. The validation results showed that all components were present and organized in accordance with learning needs, indicating that the electronic student worksheet has a complete structure. This finding is supported by research [19] , which shows that high ratings are supported by the presentation of student worksheet that contain complete and structured learning components, allowing teachers to use the student worksheet as a guide in conducting learning activities. Regarding *software* utilization, the assessment covers the indicators of interactivity, software support, and originality. The validation results indicate that the use *of Topworksheets* is deemed appropriate for presenting interactive digital instructional materials, allowing students to engage with supporting information, images, step-by-step instructions, and activities. This finding aligns with the research at [20], supported by the use of an interactive digital platform, enabling students to complete activities independently while assisting teachers in delivering and monitoring learning activities.

Regarding the application of the *Inquiry Learning* model, the assessment evaluates the alignment of activities with the stages of problem orientation, problem formulation, hypothesis formulation, data collection, hypothesis testing, and conclusion formulation. The validation results indicate that the simple experimental activities in the electronic student worksheet have been designed to follow these stages, thereby guiding students to investigate the concept of static fluids step by step. This finding is supported by research [21], which advocates for the systematic design of activities that align with the syntax of the learning model, thereby providing teachers with clear, step-by-step guidance for implementing instruction. Regarding critical thinking skills, the assessment covers indicators of interpretation, analysis, inference, explanation, evaluation, and self-regulation. Validation results show that the activities and steps in the electronic student worksheet are designed to guide students in interpreting experimental data, analyzing relationships between variables, drawing conclusions, and evaluating their own thought processes. These findings are supported by the study [22], which indicates that high scores on these assessments are supported by the presentation of questions that facilitate students' thinking processes in a focused manner.

Regarding the use of local wisdom, the assessment covered indicators of alignment with West Sumatran culture, integration with static fluid material, and clarity of presentation. This aspect received the lowest score, although it remained within the "valid" category, because not all static fluid concepts have corresponding local phenomena, resulting in an uneven distribution of local content across activities. This finding is supported by research [23], which shows that high scores are driven by the presentation of local contexts that are relevant to students' lives, making it easier for teachers to relate physics concepts to students' learning environments.

A practicality test to evaluate the product's practicality was conducted by two physics teachers and covered four aspects. The practicality results showed that presentation received the highest score based on the teachers' responses, while received the lowest score for efficiency. The high rating for the presentation aspect was due to the problems presented in the electronic student worksheet being relevant to everyday situations, the ease with which the electronic student worksheet helped students solve practice problems, and the activities within it that could be carried out easily, thereby facilitating teachers in presenting learning materials and supporting a smooth learning process in the classroom. This finding is supported by the study [24], which indicates that these high ratings stem from the worksheets' comprehensive and structured presentation of learning components, allowing teachers to use them as a guide in conducting learning activities.

A practicality test conducted by nine students on the same four components showed that the electronic student worksheet falls into the "very practical" category, as shown in Figure 7. Students rated the "benefits" component

the highest , while the "presentation" component received the lowest rating. The high benefit score is related to the activities in the electronic student worksheet that encourage students to observe phenomena, conduct simple experiments, and draw their own conclusions, allowing students to directly experience the benefits of the electronic student worksheet in understanding the topic of Static Fluids. This finding is consistent with the study [4], which shows that guided inquiry-based physics electronic student worksheet receive positive responses from teachers and students because they support student engagement in learning activities and help students understand concepts through investigative activities.

Overall, the research results show that the inquiry-based electronic student worksheet on Static Fluids which incorporates simple experiments and integrates local wisdom—has met the validity criteria and proven highly practical in the limited-scale testing phase. This product was developed to address student weaknesses identified in the preliminary analysis, particularly regarding the "bases for decision" and "inference" indicators; thus, the investigation and conclusion stages were designed to support students in using data as a basis for making decisions and drawing conclusions. The expected strengths of the product lie in the combination of inquiry activities, simple experiments that can be conducted without relying on laboratory facilities, content reflecting local wisdom that is relevant to students' lives, and critical thinking activities—all integrated into a single interactive digital electronic student worksheet. These strengths have not yet been empirically proven because the product's effectiveness has not been tested. Nevertheless, this study has limitations: the effectiveness regarding critical thinking was not tested because the research stopped at *the prototyping phase;* all validators came from a single institution and a single field of expertise, without any practicing teachers or media/ICT experts; the integration of local wisdom could still be strengthened based on validator feedback; and the presentation needs to be continuously refined based on student responses. Future research should test effectiveness during *the assessment phase* with a larger sample from multiple schools, using a pretest–posttest design or a control group, and involving validators from diverse fields of expertise.

For teachers, electronic student worksheet can be used in schools with limited laboratory facilities because the experiments are simple. Teachers play a crucial role during the investigation and conclusion phases, specifically by asking students to cite the data supporting their decisions and conclusions. Teachers can also use pretest results for each indicator to determine learning priorities and review the content displayed on students' devices before use. For developers of similar electronic student worksheet, it is recommended to involve validators from various fields of expertise, including practicing teachers and media experts, from the very beginning.

IV. CONCLUSION

Based on Plomp's Educational Design Research model—limited to the preliminary research and prototyping phases—an inquiry-based electronic student worksheet on static fluids, supported by simple experiments and integrated with local wisdom, was successfully developed as a prototype. The prototype was deemed valid, with an average Aiken's V value of 0.93 based on evaluations by five validators. The prototype was also deemed highly practical, with a practicality percentage of 93.82% based on the responses of two teachers and 90.23% based on the responses of nine students in the small-group test. The effectiveness of the electronic student worksheet in developing critical thinking skills has not yet been tested, as this study did not include *an assessment phase*.

ACKNOWLEDGMENT

The authors would like to thank all the expert validators from the Department of Physics, Universitas Negeri Padang, for their constructive suggestions and feedback during the validation of the developed electronic student worksheet. Thanks are also extended to the physics teacher and the eleventh-grade students of SMA Negeri 1 Sutera for their cooperation and participation throughout the research. The authors would also like to thank everyone who provided assistance and support in the completion of this research.

REFERENCES

[1] S. Khotimah, A. S. Bambang, Purwanti, and A. H. A. Aysi, "Enhancing the 6Cs as 21st-Century Skills Among Higher Education Students Through an Entrepreneurial Project-Based Learning," *Jurnal.: Journal Research Findings and Literature Reviews the Fields of Education, Teaching, and Learning*, vol. 10, no. 4, pp. 1528–1536, 2024, doi: https://doi.org/10.33394/jk.v10i4.13117.

[2] E. Andriana, P. S. D. Fauzany, and T. P. Alamsyah, "21st Century Multimedia Innovation: Development of E-LKPD Based on Scientific Inquiry in Science Class," *J. Innov. Educ. Cult. Res.*, vol. 3, no. 4, pp. 731–736, 2022, doi: 10.46843/jiecr.v3i4.242.

[3] S. N. Ariadila, Y. F. N. Silalahi, F. H. Fadiyah, U. Jamaludin, and S. Setiawan, "Analysis of the Importance

of Critical Thinking Skills in Student Learning," *J. Ilm. Wahana Pendidik.*, vol. 9, no. 20, pp. 664–669, 2023, doi: https://doi.org/10.5281/zenodo.8436970.

[4] R. Safitri, J. Jumadi, and N. N. Simamora, "Development of Guided Inquiry-Based Physics e-LKPD to Improve Students' Critical Thinking Abilities," *JIPF (Journal of Physics Education*, vol. 9, no. 3, pp. 353–-367

[5] J. E. Hinostroza, S. Armstrong-Gallegos, and M. Villafaena, "Roles of digital technologies in the implementation of inquiry-based learning (IBL): A systematic literature review," *Soc. Sci. Humanit. Open*, vol. 9, no. March, p. 100874, 2024, doi: 10.1016/j.ssaho.2024.100874.

[6] M. Pedaste *et al.*, "Phases of inquiry-based learning: Definitions and the inquiry cycle," *Educ. Res. Rev.*, vol. 14, pp. 47–61, 2015, doi: 10.1016/j.edurev.2015.02.003.

[7] E. K. Sitinjak, J. Marbun, I. J. Alexander, and I. Sagala, "Development of an E-LKPD on Static Fluids Based on the 7E Learning Cycle Model Using the Canva Application," *Edu Cendikia J. of Educational Sciences*, vol. 4, no. 03, pp. 897–910, 2024, doi: 10.47709/educendikia.v4i03.4856.

[8] J. J. A. Idul and M. T. M. Fajardo, "Ethnoscience-Based Physical Science Learning and Its Effects on Students' Critical Thinking Skills: A Meta-Analysis Study," *J. Math. Sci. Teach.*, vol. 3, no. 2, p. em048, 2023, doi: 10.29333/mathsciteacher/13700.

[9] C. D. Haspen and S. Syafriani, "Practicality and Effectiveness of a Guided Inquiry-Based Physics E-Module Integrated with Ethnoscience to Enhance Students' Creative Thinking Skills," *J. Res. in Physics Education*, vol. 8, no. 1, pp.. 10-16 , 2022, doi: 10.24036/jppf.v8i1.115684.

[10] R. Ramli, I. Sakti, S. Basri, R. Idamyanti, and Y. Yusdarina, "Development of Local Wisdom-Based Physics Teaching Materials for 10th-Grade Students at SMAN 4 Maros," *Karst J. Educ. and Terr.*, vol. 7, no. 1, pp. 34–42, 2024, doi: 10.46918/karst.v7i1.2266.

[11] I. A. Rizki, F. R. Mirsa, A. N. Islamiyah, A. D. Saputri, R. Ramadani, and M. Habibbulloh, "Ethnoscience-enhanced physics virtual simulation and augmented reality with inquiry-based learning: Impact on students' creativity and motivation," *Think. Ski. Creat.*, vol. 57, no. February, p. 101846, 2025, doi: 10.1016/j.tsc.2025.101846.

[12] I. M. Giawa *et al.*, "Journal of Physics Education: Development Of Physics-Based Teaching Materials Using Guided Inquiry To Improve Students' Learning," vol. 13, pp. 80–85, 2024.

[13] T. Plomp, *Design Research in Education*. Enschede: Netherlands Institute for Curriculum Development (SLO), 2013.

[14] Riduwan, *Measurement Scales for* . Bandung: Alfabeta, 2012.

[15] R. H. Ennis, "Critical Thinking Across the Curriculum: A Vision," **Topoi**, vol. 37, no. 1, pp. 165–184, 2016, doi: 10.1007/s11245-016-9401-4.

[16] Lewis R. Aiken, "Three Coefficients for Analyzing the Reliability and Validity of Ratings," *Educ. Psychol. Meas.*, vol. 45, pp. 131–141, 1985.

[17] P. D. Sundari and D. Sarkity, "High School Students' Critical Thinking Skills on Temperature and Heat in Physics Instruction," *J. Nat. Sci. Integr.*, vol. 4, no. 2, p. 149, 2021, doi: 10.24014/jnsi.v4i2.11445.

[18] M. Aulia, H. Pathoni, and J. Nurhatmi, "Development of STEM-Based Student Worksheets (LKPD) Using Arduino-Assisted Miniature Jambi Boats for the Topic of Work and *Energy*," , vol. 7, no. 3, pp. 2751–2758, 2026.

[19] M. Ires and R. Ratnawulan, "Development and Validity of an Electronic Worksheet Based on POE (Predict-Observe-Explain) to Enhance Students' Conceptual Understanding of Measurement Materials," *Phys. Learn. Educ.*, vol. 4, no. 2, pp. 165–179, 2026, doi: 10.24036/ple.v4i2.346.

[20] M. P. Nenggala, P. Razi, Hidayati, and S. Y. Sari, "Electronic Student Worksheet for Solving Problems in Physics Based on Problem-Based Learning," *Int. J. Inf. Educ. Technol.*, vol. 14, no. 7, pp. 945–954, 2024, doi: 10.18178/ijiet.2024.14.7.2121.

[21] T. Hidayat, T. Kurmalasari, Zaitun, and E. Abduulhajar, "An Assessment of the Effectiveness of Electronic Student Worksheets Based on Process-Oriented Guided Inquiry Learning (POGIL)," *Educenter: Scientific Journal of Education*, vol. 4, no. 1, pp. 2827–7988, 2025, doi: https://doi.org/10.55904/educenter.v4i1.1940

[22] M. Pabri, R. Medriati, and E. Risdianto, "Feasibility Test of Contextual E-LKPDs Supported by Liveworksheet to Develop Critical Thinking Skills in High School," *J. Sci. Educ. Phys.*, vol. 6, no. 3, p. 637, 2022, doi: 10.20527/jipf.v6i3.6812.

[23] S. Mahmudah, A. S. M., and D. Dewantara, "Development of Physics Teaching Materials Incorporating Local Wisdom to Foster Students' Critical Thinking Skills," 2023, doi: 10.20527/bipf.v11i1.14059.

[24] R. F. Rasak, Husein, and M. Hunaidah, "Pengembangan LKPD model PBL pada materi momentum dan impuls untuk meningkatkan hasil belajar siswa" (in Indonesian), *Jurnal Penelitian Pendidikan Fisika*, vol. 9, no. 3, pp. 163–170, 2024, doi: https://doi.org/10.36709/jipfi.v9i3.133