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Design and Expert Validation of an Inquiry Based Instructional Design for Basic Physics Laboratories Integrated with Local Context

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Abstract: This study aims to design and validate an inquiry based instructional design for Basic Physics laboratories integrated with local context at the higher education level. The research employed a Research and Development (R&D) approach using the ADDIE model, limited to the stages of analysis, design, development, and expert validation. The developed products consisted of a student laboratory manual and a lecturer guide structured into pre-laboratory, in-laboratory, and post-laboratory inquiry phases, with local context positioned as a source of authentic physical phenomena and problem situations. Expert validation was conducted by instructional design experts, physics content experts, and learning media experts using a Likert scale based validation instrument analyzed with Aiken's V coefficient. The validation results indicate that the instructional design demonstrates a high level of validity and feasibility across conceptual, material, and media aspects, confirming its suitability for use in Basic Physics laboratory learning. This study contributes a systematically validated instructional design framework for inquiry based physics laboratories that integrates local context as a core component of laboratory activities, providing a theoretically grounded and practically feasible design for future implementation and effectiveness studies.

Keywords: inquiry-based learning, instructional design, physics laboratory, local context, expert validation.

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1. Introduction

Laboratory learning is an integral component of physics education at the university level (Unal & Ozdemir, 2013). Laboratory activities not only serve as a medium for practice, but also as a space for students to internalize physics concepts through direct experience and build scientific thinking skills (Maunuksela et al., 2023). In the context of higher education, laboratories have a strategic role in developing *science process skills* and critical thinking skills, two competencies that are the main objectives of science learning in the 21st century. In the era of the Fourth Industrial Revolution and Society 5.0, critical thinking competencies and science process skills are crucial for graduates to adapt to complex and dynamic global challenges (Azzahra et al., 2024; Prayogi et al., 2025) .

Laboratory learning is the center of authentic experiences in physics education (Fatmaryanti et al., 2024) . Laboratory activities allow students to apply, test, and reflect on theoretical concepts in real contexts (Papalazarou et al., 2024) . However, in practice, physics laboratory activities are often still **procedural** in nature, where students only follow steps without being actively and reflectively involved in the scientific process (Holmes & Bonn, 2013; Maunuksela et al., 2023) . This approach has the potential to reduce student involvement in scientific decision-making, hypothesis development, data analysis, and understanding the relationship between real phenomena and theoretical concepts. Therefore, innovative pedagogical strategies are needed that systematically guide students to think critically, solve problems scientifically, and explore physical phenomena independently.

In an effort to improve the quality of the learning experience, inquiry-based learning design has been identified as an effective approach to facilitate active student engagement in the scientific process (R. P. Antonio & Prudente, 2023; Arifin et al., 2025; Bodner & Elmas, 2020; Kuhn et al., 2020; Pedaste et al., 2015) . The inquiry-based learning approach provides a framework for students to formulate questions, organize investigations, analyze data, and draw conclusions independently. Furthermore, a *locally-based* learning context helps bridge abstract physics concepts with students' real-world experiences, making learning more relevant and meaningful (Alhusni et al., 2025; Fitriah & Yuliati, 2025) .

Inquiry based learning is seen as an effective pedagogical strategy for overcoming these challenges because it is designed to place students as the main actors in science learning. In inquiry-based learning, students are encouraged to actively seek knowledge, formulate problems, conduct investigations, collect and analyze data, and draw conclusions based on empirical evidence (R. P. Antonio & Prudente, 2023; Chen & Chen, 2025; Morris, 2025; Muhamad et al., 2024a) . Meta-analyses discussing the effects of inquiry-based learning on critical thinking skills

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show that this approach has **a substantial effect on the development of critical thinking skills** compared to conventional approaches (Arifin et al., 2025) .

The application of inquirybased learning in physics laboratories has also been supported by empirical evidence that this type of learning not only improves conceptual skills, but also student engagement and motivation in the scientific process. For example, studies comparing inquiry-based laboratory learning with traditional approaches show that students who learn through inquiry-based learning demonstrate significant improvements in higher-order thinking skills and scientific processes (Husnaini & Chen, 2019; Muhamad et al., 2024a; Papalazarou et al., 2024b) . Critical thinking skills involve the ability to evaluate information, analyze arguments, assess evidence, and make decisions based on logical and structured reasoning (Altun & Yildirim, 2023; Calma & Davies, 2025) . Science process skills include the ability to formulate hypotheses, collect data systematically, analyze and interpret experimental results, and communicate scientific findings accurately (Ekici, 2020) . The literature shows that both types of skills are very important for physics students, but they do not automatically develop through traditional learning alone. Learning models that integrate laboratory practical activities with tasks that require scientific reflection have proven to be more effective in facilitating the development of these skills. In addition, another meta-analysis also shows that inquiry-based learning has a significant impact on improving students' critical thinking skills at various levels of science education, thus providing strong empirical support for this approach as an effective teaching strategy (Arifin et al., 2025) .

Although there is widespread evidence supporting inquiry-based learning, a limitation in the literature is that most studies have not explicitly integrated **local context** into laboratory learning design, especially at the higher education level. Local context includes natural phenomena, culture, social practices, or local resources relevant to the physics concepts studied by students (Deta et al., 2024; Fitriah & Yuliati, 2025) . The integration of local context in learning stems from the idea that learning that is relevant to students' experiences and environments will increase *the meaningfulness* and overall engagement of learning. Although specific research combining inquiry-based learning with local context in university physics laboratories is still limited, studies on the integration of local potential in science learning show that the use of local components such as culture, natural phenomena, or local resources plays an important role in developing 21st-century skills such as critical thinking and problem solving. A systematic study analyzing the literature on the integration of local potential in science learning found that the use of context-based learning media has a positive impact on 21st-century skills, including critical thinking *and* problem solving (Afkarina et al., 2024).

Integrated laboratory learning designs that incorporate local contexts have the potential to enrich students' experiences not only in terms of scientific skills, but also in terms of the social and cultural meaning of science learning. By incorporating local elements into practical activities, students can see the direct relationship between the principles of physics they are learning and the phenomena occurring in their environment. This gives students the opportunity to develop broader critical thinking skills, not only in solving abstract physics problems, but also in integrating scientific knowledge into real and relevant contexts. In addition, laboratory learning designs that take local contexts into account tend to increase student motivation and engagement, as learning feels more relevant and connected to their experiences. This is in line with findings that show that learning that connects theory with real-world practice encourages students to think reflectively and critically when encountering scientific terms and phenomena around them (Lestari, 2026) .

Although numerous studies have investigated inquiry based and active learning approaches in science education, limited attention has been given to physics laboratory learning designs that systematically integrate local context as a core component of the inquiry process. Most prior research has focused on isolated outcomes, such as critical thinking or science process skills, without embedding local phenomena into the structure of laboratory activities. To address this gap, this study develops an inquiry based physics laboratory learning design integrated with the local context of Lubuklinggau, a region with rich natural and socio cultural environments that provide authentic physical phenomena relevant to basic physics concepts. Local contexts, including river based activities along the Kelingi River, agricultural and irrigation practices, and traditional material usage, were deliberately embedded as inquiry triggers and experimental contexts for exploring fluid dynamics, pressure, work and energy, and thermal concepts. By positioning local context as an integral element across laboratory phases, this design enhances learning relevance and supports meaningful connections between physics concepts and real world phenomena, while providing a validated framework for contextual inquiry-based laboratory learning.

2. Method

Research Design

This study uses a Research and Development (R&D) approach with the ADDIE development model as a systematic framework that guides the process of designing learning, creating products, and conducting initial evaluations of learning design products for Basic Physics laboratories based on inquiry-based learning integrated with the local context of Lubuklinggau. The ADDIE model has been recognized as a

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flexible and iterative instructional design framework for producing quality teaching materials or learning systems, as each stage is interrelated and provides feedback for continuous product improvement. The stages from needs analysis to product evaluation encourage alignment between learning needs and the final instructional design developed (Arofah & Cahyadi, 2019; Spatioti & Kazanidis, 2022) .

The ADDIE model was developed by the Association for the Advancement as a learning system design as follows:

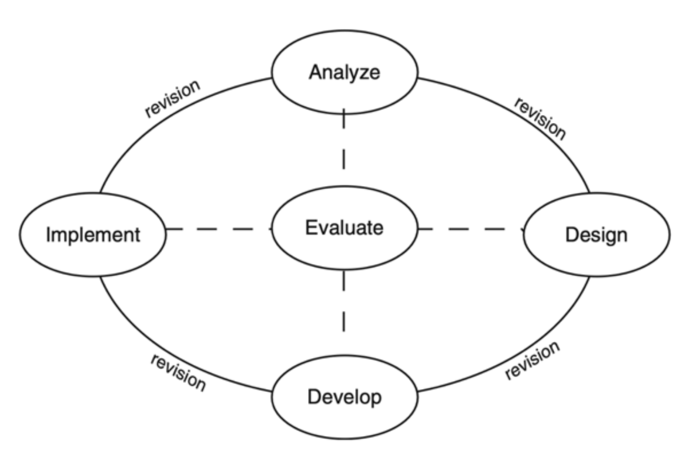

Figure 1. The ADDIE Concept

In general, there are five steps in the ADDIE model, namely Analyze, Design, Develop, Implement, and Evaluate. These steps or stages can be carried out procedurally, using an instructional design model that is not procedural or cyclical, or can be started from a certain stage, and there is also an integrative learning design model. The following is a table of the procedural stages of learning design development using the ADDIE model:

Table 1 . Instructional Design: The ADDIE Approach

Concept	***Analyze***	***Design***	***Develop***	***Implement***	***Evaluate***
	Identify the causes of problems in learning and pre-planning that considers or decides on the subjects or courses	Verify the desired outcomes or achievements (learning objectives) and determine the methods or strategies to be	Develop and validate learning resources and develop the necessary supporting materials and strategies.	Prepare the learning environment and implement learning by involving students.	Assess the quality of learning products and processes.

	to be taught.	implemented.			
General Procedures	1. Validating any gaps that occur. 2. Determining instructional objectives 3. Analyzing learners 4. Auditing possible sources 5. Determining potential delivery systems ( ) 6. Developing a project management plan	1. Conducting a task inventory 2. Establishing performance goals 3. Developing testing strategies 4. Calculating return on investment	1. Generating content 2. Sorting and developing supporting media 3. Developing guidance for students 4. Developing guidance for teachers 5. Conducting formative revisions 6. Conducting trials	1. Involving students 2. Involving teachers	1. Determining evaluation criteria 2. Selecting evaluation tools 3. Making revisions
	Analysis Summary	Brief design	Learning Resources	Implementation Strategy	Evaluation Plan

Source: (Branch, 2009)

Product Development Procedures

The product development procedure follows the operational steps of the ADDIE model, which has been adapted to the context of learning design development. Initially, the researcher conducted a needs assessment analysis to identify laboratory learning problems, gaps between current practices and students' critical thinking and science process skills, and opportunities for integrating Lubuklinggau's local cultural values into the practicum scenario. The results of this analysis were used as the basis for determining the key components of the learning design. Next, in the design stage, the researchers formulated learning objectives, compiled inquiry syntax, designed

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laboratory activity flows, and selected appropriate media and assessment instruments. In the *development* stage, the researchers compiled a draft product that included practicum guidelines, assessment rubrics, and facilitator guidelines based on the prepared design. This initial product was then prepared for validation by a panel of experts using predetermined instruments. This development process followed the general ADDIE procedure as reported in much educational R&D literature that utilizes this model to produce valid and feasible products prior to further effectiveness testing.

To provide a more comprehensive overview of the direction and structure of product development, this study developed a conceptual framework that served as the basis for the design of laboratory learning. This framework functions as a conceptual map that guides the design process, starting from the identification of needs, the formulation of learning objectives, the design of inquiry-based laboratory activities, to the integration of local context elements. The following is a presentation of the inquiry-based laboratory learning design framework that serves as the main reference in the product development process of this research.

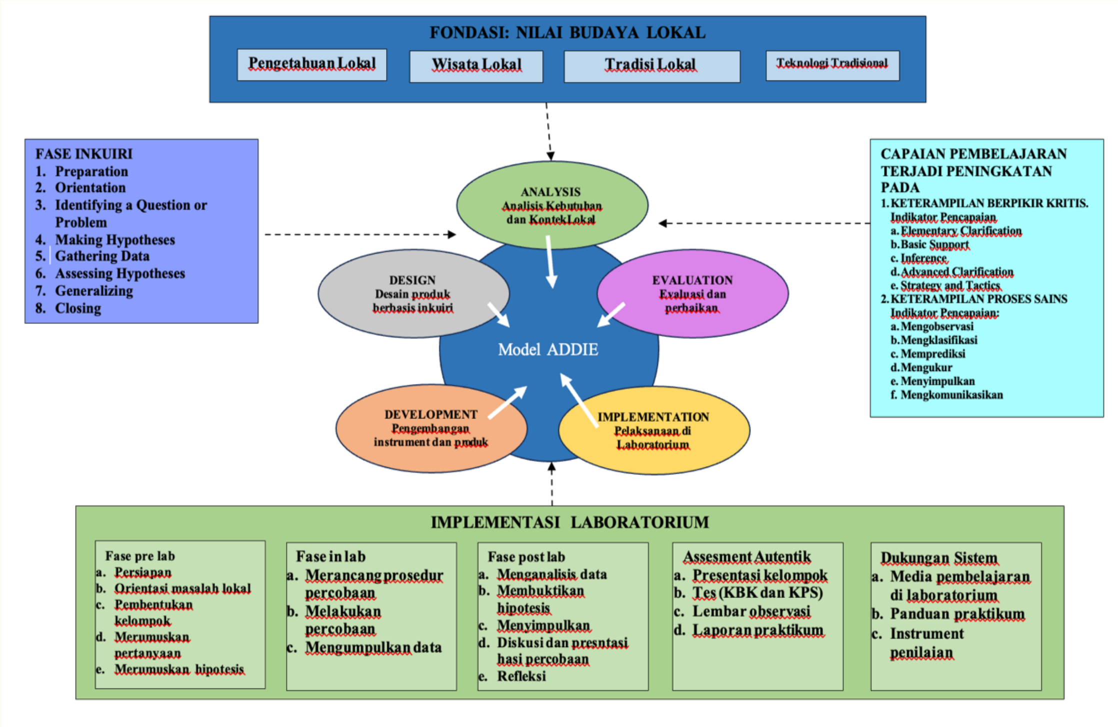

Figure 2. Design framework for physics laboratory learning based on inquiry based learning integrated with the local context

Expert validation procedure

The expert validation stage was conducted to ensure that the instructional design products developed met high pedagogical and technical standards and were able to reflect the appropriate integration of the *inquiry* approach and local context.

Validation was carried out by involving a panel of experts who were purposively selected based on their competence in their respective fields. The experts assessed the initial products using a 5-point Likert scale-based validation instrument designed to evaluate conceptual, material, and media aspects. The product package was submitted to the expert panel along with assessment guidelines for each assessment domain, including content relevance, conceptual accuracy, *inquiry* flow quality, and media integration with learning objectives. The expert panel was asked to provide quantitative scores and qualitative comments for each item, enabling researchers to make revisions and improvements based on their feedback. This procedure is consistent with the instrument validation practices recommended in educational research to ensure the content validity of a product before it is widely used in the implementation of learning .

Validation instrument

The instruments used in this study were specifically designed to fulfill the function of product validation up to the final revision stage. These instruments consisted of *expert validation sheets* containing assessment items for three groups of experts: conceptual experts (instructional design), subject matter experts (physics content), and media experts (appearance and quality of learning media). The instructional design expert validation sheet is designed to assess the extent to which the learning design meets the principles of the ADDIE model and the *Inquiry-Based Learning* approach, as well as to ensure that the integration of the local context is pedagogically sound and relevant. This sheet covers eight main assessment aspects, namely: the suitability of instructional objectives with CPL and 21st-century skills; the sustainability of the learning process; the quality of IBL syntax application; the logic of the instructional design structure; the accuracy of local context integration; the encouragement of active student engagement; the suitability of media and tools for experimental needs; and the measurability of learning evaluation. The instrument for subject matter experts was developed to evaluate the suitability of basic physics content presented in the laboratory manual. The assessment grid is divided into six main aspects, namely: content feasibility (suitability of material with CPL and CPMK, correctness of work procedures, and accuracy of scientific concepts), completeness of material, presentation of material, accuracy of material, suitability with language rules, relevance to the inquiry approach, and integration of local context. Meanwhile, the media expert validation sheet assesses the quality of the appearance and functionality of the learning media used in the practicum guide, which covers three major aspects, namely: the size and physical quality of the guide, the cover design, and the design of the practicum guide content. This assessment focuses on aesthetics, visual consistency, readability, the quality of graphics and tables, and the suitability of the layout for the practicum objectives.

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Validation analysis techniques

Data analysis in this laboratory instructional design development study was conducted quantitatively and qualitatively to ensure the accuracy, consistency, and feasibility of the product before it was used in the next implementation stage. The analysis techniques used included content validity analysis using Aiken's V coefficient. This approach is commonly used in instrument and learning device development research because it provides objective numerical estimates and categorization of product quality. Data from expert validation assessments of the feasibility of the developed product. Data validity was validated using a scale of 1-5. The assessment scale table is presented in Table 3.

Table 3. Validation Questionnaire Scale

Description	Statement
5	Very Good
4	Good
3	Fair
2	Poor
1	Very Poor

The validity test conducted by the validator was then analyzed using Aiken's V validity analysis. This technique is based on the results of expert (rater) assessments by n people on specific items. The Aiken's V validity coefficient can be calculated as follows:

$$V = \frac{\sum S}{n(c-1)}$$

The explanation is as follows:
V = content validity coefficient
n = number of raters
s = *r* – *lo*
c = the highest validity rating score (5)
lo = lowest validity score (1)
r = rater score

The resulting *V* value is then interpreted using the validity criteria of Aiken's (Aiken, 1985) . The V value ranges from 0 to 1, where the interpretation refers to the minimum feasibility threshold according to and is reinforced by various recent publications:
V ≥ 0.80 = highly valid/suitable for use,
0.60 ≤ V < 0.80 = sufficiently valid / requires minor revision,
V < 0.60 = less valid / major revision required.

3. Result and Discussion

Results of Laboratory Learning Design Development

This study produced a basic physics laboratory learning design based on inquiry integrated with the local context, which was packaged in the form of a student practicum guide and a lecturer guide. This learning design was systematically compiled with reference to the stages of inquiry learning that emphasize students' active involvement in the scientific process, ranging from problem formulation to concept generalization. The structure of laboratory activities is organized into pre-laboratory, in-laboratory, and post-laboratory stages, which are operationalized through inquiry steps including orientation, identifying questions, formulating hypotheses, collecting data, analyzing data, drawing conclusions, and reflection. The integration of the local context of Lubuklinggau is implemented through the selection of phenomena, illustrations, and physics problems that are closely related to students' daily experiences, thereby making learning more contextual and meaningful. The results of the development indicate that this laboratory learning design moves beyond a verificative approach and instead encourages students to construct knowledge through independent and collaborative scientific inquiry processes.

In the developed laboratory learning design, the local context of Lubuklinggau is operationalized as a source of inquiry problems and practical exercises. For example, the operation of the Lubuklinggau railway system is used as a contextual basis for laboratory activities on uniform linear motion (GLB) and uniformly accelerated motion (GLBB). Students are presented with problem situations related to constant-speed motion and acceleration during train departure and braking, which are subsequently translated into controlled laboratory experiments using motion tracks and time–distance measurements. Another example is the local practice of *Nggegai Duku*, which is integrated into laboratory activities on free-fall motion. This traditional activity provides a real-life context for investigating gravitational acceleration by observing falling objects and comparing empirical observations with experimental data obtained under laboratory conditions. A further example is the traditional activity of drawing water using a pulley system (*menimba air menggunakan katrol*), which is employed as a contextual source for laboratory exercises on particle dynamics. Through this context, students explore force, tension, and mechanical advantage by reconstructing the water-lifting process in a laboratory pulley system, allowing them to analyze physical principles through inquiry-based experimentation.

To clarify how inquiry scaffolding is operationalized in the developed design, an example of inquiry-based laboratory activities is presented. For the practicum topic of uniform linear motion (GLB) and uniformly accelerated motion (GLBB) integrated with the Lubuklinggau railway context, the pre-laboratory phase introduces students to a contextual problem related to train motion and guides them to identify relevant variables, formulate investigable questions, develop hypotheses, and plan experimental procedures. During the in-laboratory phase, students design and conduct motion experiments using laboratory models that represent train movement, collect distance time data, and record observations systematically with guided worksheets. In the post-laboratory phase, students analyze the data to determine velocity and acceleration, interpret motion graphs, evaluate hypotheses, and draw evidence-based conclusions. Reflective prompts support connections between experimental results and real railway phenomena while encouraging consideration of model limitations. Figure 3 presents a diagram of the inquiry-based physics laboratory learning design integrated with the local context of Lubuklinggau.

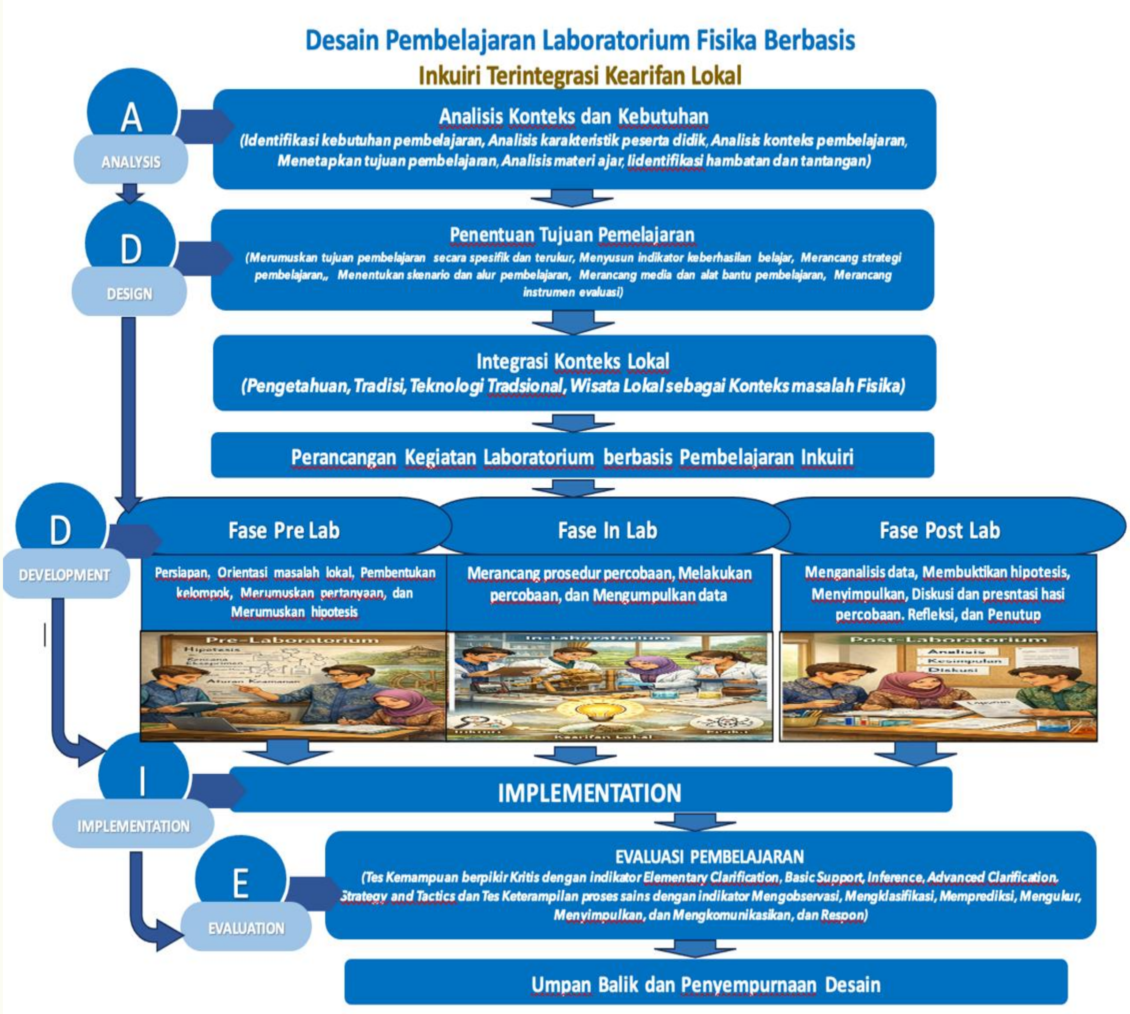

Figure 3. Inquiry based physics laboratory learning design

The chart illustrates **the flow of inquiry based physics laboratory learning design integrated with local wisdom**, which was systematically developed with reference to the ADDIE model, starting from the analysis stage to the evaluation and refinement of the design. In the **analysis** stage, learning design begins with an analysis of the context and learning needs. This stage includes identifying learning needs, analyzing student characteristics, analyzing the laboratory learning context, setting initial learning objectives, analyzing teaching materials, and identifying obstacles and challenges encountered in basic physics practicum learning. This analysis is the main foundation for ensuring that the design developed is relevant to student needs and the real conditions of laboratory learning.

The next stage is **design**, which focuses on determining specific and measurable learning objectives. At this stage, learning success indicators are formulated, inquiry-based learning strategies are designed, laboratory learning scenarios and flows are developed, and media, teaching materials, and evaluation instruments that are in line with the learning objectives are designed. This phase also involves **the integration of local contexts**, including local knowledge, traditions, traditional technologies, and local tourism potential as contexts for physics problems, so that learning becomes contextual and meaningful for students. **The development** stage is realized in the design of inquiry-based laboratory activities structured into three main phases, namely **the pre-lab phase, the in-lab phase, and the post-** In the pre-lab phase, students make initial preparations, orient themselves to context-based problems, form groups, formulate research questions, and develop hypotheses. The in-lab phase focuses on core practicum activities, including designing experimental procedures, conducting experiments, and collecting data. Next, in the post-lab phase, students analyze data, prove hypotheses, conclude experimental results, conduct discussions and presentations, and reflect on the learning process and outcomes. The **implementation** stage is the stage of applying the laboratory learning design that has been developed in basic physics practicum activities in a real learning environment. At this stage, all components of the design, from practicum guidelines and inquiry strategies to the integration of local contexts, are fully implemented in laboratory activities.

The final stage is **evaluation**, which aims to assess the effectiveness of the learning design. Evaluation is carried out by measuring students' critical thinking skills using indicators of *elementary clarification, basic support, inference, advanced clarification, and strategy and tactics*, as well as measuring science process skills through indicators of observing, classifying, predicting, measuring, concluding, and communicating. In addition, the evaluation also includes collecting responses from students and lecturers regarding the implementation and usefulness of the learning design. This entire series of stages ends with **feedback and refinement of the design**, which forms the basis for continuous improvement of the integrated inquiry-based physics laboratory learning design with local wisdom so that it becomes more valid, effective, and contextual.

Expert Validation Results

Expert validation was conducted to ensure the feasibility of the instructional design developed prior to its implementation in field trials. Validation involved three groups of experts, namely conceptual experts, physics experts, and media experts. Each expert assessed aspects according to their competence using a structured assessment sheet with a Likert scale.

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a. Conceptual Validation

Conceptual validation was conducted to assess the accuracy of the instructional design in terms of conceptual alignment, design structure, integration of the inquiry approach, and the relationship between theory and learning interventions. Two instruments were used in this validation, namely **a design questionnaire** and **a questionnaire on the relationship between theory and intervention**. Both questionnaires provide a comprehensive picture of the conceptual quality of the instructional design before it is applied in the empirical testing stage. The results of the design questionnaire validation analysis can be seen in Table 3 below:

Table 3. Validation Results of the Design Questionnaire s of Inquiry-Based Physics Laboratory Instruction

No	Aspect	Indicator	$\sum s$	V
1	Goal Alignment	Instructional objectives are consistent with learning outcomes (CPL)	11	0.917
		Objectives include critical thinking skills and the scientific process.	11	0.917
2	Process Continuity	The learning flow supports a systematic inquiry process.	11	0.917
		The learning steps are easy for students to follow.	10	0.833
3	Learning Model (Inquiry-Based Learning)	Clarity and completeness of the inquiry approach used in the design	12	1,000
4	Instructional Design Structure	The components of instructional design are arranged logically and systematically.	10	0.833
		The design includes all necessary learning elements (objectives,	11	0.917

		materials, evaluation, etc.).		
5	Integration of Local Wisdom	The learning materials are relevant to the selected local contexts.	10	0.833
		Local wisdom is used to support the development of critical thinking skills and scientific process skills.	10	0.833
6	Student Engagement	Instructional design encourages students to actively participate in discussions.	11	0.917
		Students are invited to participate in inquiry-based experiments.	11	0.917
7	Suitability of Media and Tools	The learning media is suitable for supporting experiments in the laboratory.	11	0.917
		The tools used are relevant to the science process skills being taught.	11	0.917
8	Measurability of Evaluation	Learning evaluation reflects the achievement of critical thinking skills.	11	0.917
		Evaluation instruments in accordance with inquiry-based learning stages	11	0.917
		Total	0.897	
		Criteria	HIGH	

Overall, the results of conceptual expert validation of the developed learning design show that the developed design is at a high level of feasibility. With an Aiken's V value of 0.897, the learning design is declared feasible for implementation at the empirical testing stage without requiring major revisions. These results reinforce that the developed design has met the conceptual, structural, and pedagogical feasibility

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standards in the context of inquiry-based physics laboratory learning integrated with local wisdom. The expert validation process in the early stages of instructional development is an important step to ensure *content validity*, namely the extent to which the design components truly reflect the desired construct, as emphasized in various methodological studies on the development of educational instruments (Luque-vara et al., 2020; Saiful & Yusoff, 2019) .

The second questionnaire was used to assess the extent to which the developed learning intervention was consistent with the theories underlying the research. The assessment included the compatibility between theory and research objectives, the alignment between theory and intervention, the relevance of the intervention to the research variables, and the strength of the conceptual arguments underpinning the intervention. The results of the validation analysis of the questionnaire validating the relevance between theory and intervention are shown in Table 4 below:

Table 4. Results of the questionnaire validation analysis of the relationship between theory and intervention

No	Aspect	Indicator	$\sum s$	V
1	Consistency between Theory and Research Objectives	The inquiry learning theory has been appropriately used to support the goal of improving students' critical thinking skills.	11	0.917
		The integration of local context into learning design has a strong and relevant theoretical foundation.	10	0.833
		The learning design developed is in line with constructivist learning theory or other relevant theories.	9	0.750
2	Alignment between Theory and Intervention	The designed intervention (inquiry-based laboratory learning) reflects the principles of the learning theory used.	10	0.833

		's instructional intervention steps reflect the stages in inquiry learning theory.	10	0.833
		Activities in the intervention allow for the application of local context principles based on relevant literature or theory.	11	0.917
3	The Relationship Between Intervention and Research Variables	The designed intervention has the logical potential to improve students' critical thinking skills.	11	0.917
		The developed intervention is also suitable for improving students' scientific processes.	12	1.000
		The relationship between the intervention, theory, and research variables is explained explicitly and consistently.	11	0.917
4	Clarity and Strength of Conceptual Arguments	The theoretical review is systematically organized to establish the basis for intervention.	10	0.833
		The explanation of the theory and its application in interventional design can be clearly understood by readers.	11	0.917
		Conceptual arguments show a strong relationship between theory, local context ,	10	0.833

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and learning interventions.	
Number	0.875
Criteria	High

The results of validation through the Questionnaire on the Relationship between Theory and Intervention obtained a high Aiken's V score, indicating that the learning intervention is strongly aligned with the theoretical basis used, namely inquiry learning theory, constructivism, and literature related to local wisdom. The designed intervention was assessed to be consistent with the principles and stages of inquiry, having the logical potential to improve students' critical thinking and science process skills, and supported by clear, systematic, and strong conceptual arguments. Overall, these two validation results confirm that the developed instructional design is feasible for implementation at the empirical testing stage without major revisions. These findings are in line with the opinion of which shows that a theoretically strong inquiry design has a significant impact on improving critical thinking abilities and science process skills. Expert validation that shows the argumentative strength and coherence between intervention theories is an indication that the intervention has *logical pedagogical potential* to produce changes in student abilities as expected.

b. Material Validation

To obtain a more comprehensive picture of the level of suitability of the material in the practicum guide, a quantitative analysis was conducted using Aiken's V index on all assessment items in terms of content suitability, material completeness, Material Presentation, Material Accuracy, Conformity with Language Rules, Relevance to inquiry-based learning, and Integration of Lubuklinggau Local Wisdom. Aiken's V calculations were based on the assessments of two expert validators who are competent in the fields of physics education and learning tool development. The Aiken's V values for each item are presented to show the consistency, quality, and contribution of each item to the overall validity of the material. Details of the assessment results are presented in Table 5 below.

Table 5. Results of Content Expert Validation with Aiken V

No	Aspect	Indicator	$\sum s$	V
	Content Suitability	Alignment of materials with CPL-PRODI (Program Study Learning Outcomes) and CPMK (Course Learning Outcomes)	8	1.0

		The work procedures presented are in accordance with the applicable presentation methods, logical, and correct.	8	1.0
		The practical activities presented are in accordance with scientific concepts and are not confusing.	7	0.875
2	Completeness of Materials	The materials presented in the Basic Physics I Practical Guide are complete.	7	0.875
		The materials presented in the Basic Physics I Laboratory Manual are systematically organized.	7	0.875
		The learning objectives in the Basic Physics I Laboratory Manual are clearly outlined.	8	1.00
		The steps in the Basic Physics I Practicum Guide are easy for students to understand.	7	0.875
		The experimental data in the Basic Physics I Laboratory Manual supports the achievement of learning objectives.	8	1
3	Presentation of Material	The presentation of material in the Basic Physics I Laboratory Manual begins with easy topics and progresses to more difficult ones.	8	1.00
		The presentation of the laboratory manual in the Basic Physics Laboratory Manual I helps students discover concepts.	7	0.875

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		The presentation of images or illustrations in the Basic Physics I Laboratory Manual supports the explanation of concepts.	7	0.875
		The presentation of material in the Basic Physics I Practicum Guide is in line with everyday life.	7	0.875
		The presentation of examples or phenomena in the Basic Physics I Laboratory Manual is consistent with real-life situations.	7	0.875
4	Accuracy of Material	The concepts and definitions in the Basic Physics I Laboratory Manual do not give rise to many interpretations.	8	1
		The images, illustrations, and tables presented in the Basic Physics Laboratory Manual I are accurate.	7	0.875
		The formulas, symbols, and units used in the Basic Physics Laboratory Manual I are accurate.	8	1.00
		The material presented in the Basic Physics I Practical Guide is in line with current scientific developments.	7	0.875
5	Compliance with Language Rules	The language used is appropriate for the emotional maturity level of the students.	7	0.875
		The sentence structure used by to convey messages refers to the rules of good and correct Indonesian grammar.	7	0.875

		The spelling used refers to the Enhanced Spelling Guidelines.	7	0.875
6	Relevance to Inquiry	The material is packaged with an appropriate inquiry approach	6	0.750
		Practical guidelines are presented using an appropriate inquiry-based approach.	6	0.750
7	Integration of local wisdom	Integration of local wisdom with the concept of physics	8	1.0
		Clarity and coherence of the integration of local wisdom	7	0.875
		Relevance of local wisdom to daily life	8	1
		Total	**98**	**0.910**
		Criteria	**High**	

The assessment results show that most items obtained a **high** Aiken's V validity coefficient score, with a range of 0.875 to 1.000 for the majority of indicators. Several items obtained a **moderate** score (V = 0.750), but the number was very small and did not affect the overall consistency of the assessment. Cumulatively, the material validation produced **an Aiken's V value of 0.910**, which is in the **high** category, so that the practicum guide material was declared to meet the standards of substance, conceptual accuracy, completeness of description, and suitability with the characteristics of inquiry-based learning and local wisdom content. These results confirm that the guide provides a logical material structure, communicative language, and relevant local context integration to support student learning experiences in Basic Physics I laboratory activities.

The high validity of items assessing the relevance of material to the inquiry approach indicates that the practicum guide successfully combines the steps of scientific investigation: formulating problems, designing experiments, collecting and analyzing data, and drawing conclusions. Research on inquiry-based instructional design confirms that learning tools that are aligned with the stages of inquiry will increase students' cognitive engagement and encourage critical thinking skills and scientific process skills (Nuzulah et al., 2023) .

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c. Media Validation

The quality of the practical guide media was analyzed using Aiken's V index to ensure that the visual and design aspects met the standards of learning media feasibility. Media validation included an assessment of three main aspects, namely Guide Size, Cover Design, and Content Design, which were assessed by two expert validators experienced in instructional design and educational media development. The presentation of Aiken's V values for each item aims to provide an objective description of the accuracy of visual design, layout consistency, and the effectiveness of the media in supporting the clarity of material presentation. The complete results of the assessment of each item can be seen in Table 6 below.

Table 6. Expert Media Validation Results with Aiken V

No	Aspect	Indicator	$\sum s$	V
1	Size Basic Physics I Laboratory Manual	The quality of the paper used	7	0.875
		Layout quality of the Basic Physics I Laboratory Manual	7	0.875
		Size of the Basic Physics I Laboratory Manual in accordance with ISO standards	7	0.875
		User comfort and ease of mobility	7	0.875
		Consistency of size across all pages	8	1.00
2	Cover Design for Basic Physics I Laboratory Manual	Color background consistency in the Basic Physics I Practicum Guide	7	0.875
		Balance between illustrations and text	7	0.875
		The cover illustration can describe the contents of the Basic Physics I Laboratory Manual	7	0.875
		The font style and size used are easy to read.	8	1
		The layout of the elements on the cover is neat and balanced.	7	0.875

3	Design of the Basic Physics I Laboratory Manual	The color combination in the contents of the practical guide is harmonious and attractive	6	0.750
		Consistency in writing physics symbols	7	0.875
		Tables and graphs are clear and informative	8	1
		The suitability of the material and images in the Basic Physics I Laboratory Guide with the laboratory objectives	8	1.99
		Readability of text (*font*, size, spacing)	8	1.0
		Total	**93**	**0.908**
		Criteria	**Height**	

Media validation was carried out to assess the quality of the appearance and design of the practicum guide based on three aspects, namely **Guide Size**, **Cover Design**, and **Content Design**. The two expert validators provided assessments through a number of items covering visual readability, layout consistency, font size proportionality, neatness of layout, and suitability of design to the character of the practicum material. The analysis results showed that most items obtained an Aiken's V coefficient in the **high** category (0.875–1.000), with one item in the **moderate** category (0.750). Overall, the total media validity score reached **Aiken's V = 0.908**, which is in the **high** category. These findings prove that the practicum guide has met the media design quality standards, both in terms of aesthetics and functionality, making it easy to use, professional in appearance, and capable of supporting students' understanding of the material content. The suitability of the document size, the informative and representative cover design, and the systematic layout of the content indicate that this guide is suitable for use as a supporting medium in Basic Physics I laboratory learning.

This high Aiken's V score is in line with findings in a number of educational studies which show that learning media with high content validity scores tend to be more suitable for use in learning contexts because they reflect the suitability of the content and form of the media to the learning objectives (Kurnia et al., 2025) . Well-validated media are usually easier for students to use because their structure and neat appearance support understanding of the material. This is supported by the literature on learning media validation, which states that media with high validity indices

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contribute to improving the overall quality of learning (Kosandi, 2024; Sari et al., n.d.; Wisdayana et al., 2025) .

4. Discussion

This study aims to develop and validate an inquiry-based physics laboratory learning design integrated with the local context. Expert validation results show that the developed learning design has a high level of feasibility in terms of conceptual, material, and media aspects. These findings indicate that the learning design has met the pedagogical, theoretical, and technical principles necessary to support meaningful physics laboratory learning in higher education. The high conceptual validity indicates that the laboratory learning design has successfully internalized the main principles of inquiry-based learning, namely the active involvement of students in formulating problems, developing hypotheses, conducting investigations, analyzing data, and reflecting on learning outcomes. These findings are in line with previous studies that confirm that inquiry-based laboratory learning is able to shift the role of students from merely performing procedures to being the main actors in the process of constructing scientific knowledge (D. Antonio et al., 2022; Muhamad et al., 2024c) . This type of laboratory design has proven effective in fostering higher-order thinking skills, particularly critical thinking and scientific reasoning (D. Antonio et al., 2022; Blumer & Beck, 2019; Erkacmaz & Bakirci, 2023; Muhamad et al., 2024b; Thacker, 2023) .

The strong consistency between learning theory and the developed intervention shows that this design is rooted in the constructivist paradigm. Within the constructivist framework, learning is viewed as an active process involving interaction between empirical experience, prior knowledge, and cognitive reflection (Kwan & Wong, 2015) . The structure of the pre-laboratory, in-laboratory, and post-laboratory activities designed in this study serves as systematic scaffolding to facilitate the students' inquiry process. This approach is in line with recent research findings that emphasize the importance of a clear inquiry structure in improving the quality of laboratory learning in higher education (Guitart, 2025) .

One of the main contributions of this study is the systematic and pedagogical integration of local context into the design of physics laboratory learning. Expert validation results show that local context not only serves as an additional illustration, but also functions as a source of authentic problems and phenomena that support the inquiry process. This integration of local context strengthens the relevance of learning and helps students relate abstract physics concepts to the reality of their surroundings. These findings are in line with research stating that real-context-based science learning can improve meaningful learning, student engagement, and the ability to transfer concepts to new situations (Afkarina et al., 2024; Fitriah & Yuliati, 2025; Muratova & Grishnova, 2023) .

High material validity indicates that the developed laboratory manual has met the standards of conceptual accuracy, substantive completeness, and suitability for inquiry-based learning characteristics. This is important considering that many previous studies have reported that physics laboratory activities are still dominated by a verificative approach that limits the development of students' science process skills (Holmes & Bonn, 2013; Maunuksela et al., 2023) . By integrating tasks that require hypothesis formulation, experimental decision-making, and evidence-based data analysis, this learning design has the potential to improve science process skills such as observation, measurement, data interpretation, and scientific communication (Ekici, 2020; Muhamad et al., 2024a) . In addition, the results of media validation show that the practicum guide has visual and structural qualities that support the implementation of learning. Well-designed learning media play an important role in reducing irrelevant cognitive load and helping students focus on the inquiry process (Becker et al., 2020; Mutlu-Bayraktar et al., 2019) . These findings are in line with research showing that consistent, easy-to-read, and logically structured media design contributes to the effectiveness of laboratory learning and user comfort (Candido & Cattaneo, 2025) . Overall, the results of this study address gaps in the literature related to the design of physics laboratory learning in higher education. Most previous studies tend to separate the study of inquiry-based learning and context-based learning, or only focus on testing effectiveness without presenting a systematically validated design framework. This study fills this gap by presenting an inquiry-based laboratory learning design that is integrated with the local context and validated through comprehensive expert assessment.

The novelty of this research lies in the development of a physics laboratory learning design that not only adopts an inquiry-based learning approach but also integrates local context as a core component in each phase of laboratory activities (pre-lab, in-lab, and post-lab) and is systematically validated through a Research and Development approach. Unlike previous studies that generally utilize local context as enrichment or contextual examples, the design developed in this study, " ," places local context as a trigger for inquiry, a source of problems, and a basis for students' scientific reflection. Thus, this study provides a theoretical contribution in the form of a structured and replicable contextual inquiry laboratory learning design framework, as well as a practical contribution in the form of valid and ready-to-implement practicum guidelines to support the development of students' critical thinking and science process skills.

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This study is subject to several limitations that should be considered when interpreting the findings. First, the scope of the present research is limited to the design and expert validation stages of the inquiry-based physics laboratory learning design integrated with local context. The study does not include field trials involving large-scale student implementation, nor does it examine the direct impact of the developed design on students' critical thinking skills (CT) or science process skills (SPS). Therefore, the findings should be interpreted as evidence of design feasibility, conceptual coherence, and pedagogical validity rather than instructional effectiveness. Second, the validation process relied on expert judgment using structured instruments, which, although appropriate for establishing content validity, does not provide empirical evidence of learning outcomes. Student responses and classroom dynamics during real laboratory implementation were not systematically observed or measured in this study.

Based on these limitations, a clear research roadmap is proposed for subsequent stages. The first follow-up stage involves a limited field trial to examine the practicality and usability of the laboratory design in authentic learning settings. This stage may employ a one-group pretest–posttest design to obtain preliminary evidence of changes in students' CT and SPS after using the inquiry-based laboratory activities. The second stage may involve a quasi-experimental design with a comparison group, allowing for more rigorous testing of the effectiveness of the developed design against conventional laboratory instruction. Quantitative data from validated CT and SPS instruments can be complemented with qualitative data, such as student reflections and observational records, to capture learning processes more comprehensively. In the final stage, a mixed-method research approach is recommended to integrate quantitative outcomes with qualitative insights. This approach would enable deeper analysis of how inquiry scaffolding and local context contribute to the development of CT and SPS, as well as how students experience and interpret the laboratory learning process. Through this staged research roadmap, the inquiry-based laboratory learning design developed in this study can be systematically refined and empirically tested for its educational impact.

5. Conclusion

This study successfully developed an inquiry based Instructional Design for Basic Physics Laboratories Integrated with Local Context through a Research and Development approach using the ADDIE model. The resulting products were student practicum guides and lecturer guides that were systematically designed to facilitate the inquiry process from the problem orientation stage to the reflection of learning outcomes, with the local context as a source of authentic physics phenomena and problems. Expert validation results showed that the developed learning design had a high level of feasibility in terms of conceptual aspects, material, and media. Conceptual validation confirms a strong alignment between inquiry learning theory, learning design structure, and the objectives of developing students' critical thinking and science process skills. Content validation confirms that the physics content presented is accurate, systematic, and in line with the characteristics of inquiry learning, while media validation shows that the practical guide has good visual quality and readability, thereby supporting the effective implementation of laboratory learning. The findings of this study confirm that the integration of local context into the design of physics laboratory learning not only increases the relevance and meaningfulness of learning but also has the potential to strengthen students' cognitive engagement in the scientific inquiry process. By placing local context as a core component in each phase of laboratory activities, the developed learning design is able to bridge abstract physics concepts with students' real experiences. Overall, this research provides a theoretical contribution in the form of a systematically validated framework for inquiry based physics laboratory learning design integrated with local context, as well as a practical contribution in the form of a practicum guide that is suitable for use in basic physics learning in higher education. Although this research is still limited to the development and expert validation stages, the results obtained show strong pedagogical potential for improving students' critical thinking and science process skills. Further research is recommended to test the effectiveness of this learning design through field implementation and empirical measurement of its impact on student learning outcomes.

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