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A Plant Physiology Practicum Guide Using Pineapple Peel Liquid Organic Fertilizer: Content Validity Analysis with Aiken's V

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Abstract: A valid practicum guide is essential for supporting systematic, contextual, and scientifically oriented plant physiology learning. This study aimed to develop a plant physiology practicum guide using pineapple peel liquid organic fertilizer and to analyze its content validity using Aiken's V. The study employed a research and development method based on the 4D model, comprising the Define, Design, Develop, and Disseminate stages, but implementation was limited to the Develop stage, specifically expert validation and product revision. The guide incorporates concepts of mineral nutrition and vegetative growth, procedures for producing pineapple peel liquid organic fertilizer, treatments at different concentrations, measurement of growth parameters, data recording, and analytical questions. Validation was conducted by three experts using a four-point instrument covering content, language, and presentation. Data were analyzed using Aiken's V coefficients and 95% confidence intervals at the item level. The results showed Aiken's V values of 0.794 for content, 0.952 for language, and 0.746 for presentation, with an overall coefficient of 0.831. The language aspect showed the strongest expert agreement descriptively, whereas presentation was identified as the main priority for improvement, particularly in color harmony, layout consistency, numbering, and organization. Thus, the guide demonstrated evidence of content validity based on expert judgment and, after revision, is suitable for further practicality and effectiveness testing; this study did not evaluate its practicality or effectiveness.

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INTRODUCTION

Plant physiology is a branch of biology that examines various life processes in plants, including water and nutrient uptake, substance transport, photosynthesis, respiration, growth, development, and plant responses to environmental changes. These topics cannot be adequately understood through conceptual explanations alone because most physiological processes are dynamic and are influenced by interactions among various internal and external factors. Therefore, plant physiology instruction should provide students with opportunities to conduct observations, measurements, experiments, data analyses, and evidence-based interpretation. Well-designed laboratory activities can help students connect theory with directly observed biological phenomena while developing their ability to engage in scientific inquiry (Schnell et al., 2021; Nur et al., 2025).

Practicum activities are an important component of plant physiology instruction because they provide students with direct experience in identifying variables, designing or following experimental procedures, using equipment, recording physiological changes, processing data, and communicating observations. However, the success of a practicum depends not only on the availability of laboratories and equipment but also on the quality of the guide used. A practicum guide serves as a framework that directs students from preparation and implementation through observation, data processing, and conclusion drawing. Research on plant physiology practicum activities indicates that procedural clarity, readiness of tools and materials, time management, guidance, and evaluation are important factors in ensuring effective implementation (Nur et al., 2025).

A high-quality practicum guide should not merely contain procedural steps to be followed mechanically. It should provide students with opportunities to understand the objectives of an activity, formulate problems, connect theory with observations, organize data, explain patterns in the results, and evaluate possible sources of error. Inquiry-based and research-oriented practicum guides have been reported to support more student-centered learning, develop thinking skills, and help students conduct investigations more systematically (Wulandari, 2021; Thahir et al., 2021). Previous development studies of plant physiology practicum guides have also shown that systematically designed products should meet criteria of validity, practicality, and relevance to students' needs and the conditions of the laboratory in which the practicum is conducted (Arif & Maya, 2019; Thahir et al., 2021).

One strategy for making practicum activities more meaningful is to integrate environmental issues and local resources into experimental activities. A contextual approach allows students to learn plant physiology concepts through phenomena that are closely related to their everyday environment. Easily accessible local materials can be used as experimental objects so that practicum activities not only explain biological concepts but also encourage students to understand resource utilization, waste management, and the application of scientific knowledge to environmental problem solving. In this context, pineapple peel waste has the potential to be used as a raw material for liquid organic fertilizer and as a learning resource in plant physiology practicum activities.

Pineapple consumption and processing generate waste in the form of peels, cores, crowns, leaves, and residual fruit flesh. Pineapple peels contain organic matter and various components that can still be converted into useful products. If not properly managed, readily degradable organic fractions can increase the waste burden. Conversely, pineapple waste can be utilized through various valorization pathways, including fermentation, composting, vermicomposting, and processing into value-added products. Such utilization supports a circular approach because materials previously regarded as waste can be returned to a productive use cycle (Aili Hamzah et al., 2021).

Fermenting pineapple peels into liquid organic fertilizer is a form of waste utilization that can be relatively easily implemented in educational laboratory activities. The fermentation process allows students to learn about organic matter decomposition, microbial activity, changes in material characteristics, and the use of fermentation products as sources of plant nutrients. The resulting product can then be used to examine the relationship between fertilizer solution concentration and plant growth responses. Thus, a single practicum sequence can integrate concepts of microbial metabolism, mineral nutrition, plant growth, morphometric measurement, and organic waste management.

The use of pineapple waste as an organic material for agriculture has been investigated in several forms. Pre-composting and vermicomposting can help stabilize pineapple waste and produce organic material that is more suitable for reuse (Castillo-González et al., 2019). Controlled vermicomposting systems can also facilitate nutrient recovery from pineapple waste for reuse in plant production (Zziwa et al., 2021). These findings strengthen the rationale for using pineapple peel waste as an experimental context that connects organic waste management with plant nutrition and growth.

Pineapple peel liquid organic fertilizer also has potential as an experimental material for investigating plant responses to different nutrient concentrations. Research on shallots has shown that plant responses to pineapple peel liquid organic fertilizer are related to its concentration and application frequency (Cristina et al., 2022). Another study on red lettuce used several concentrations of pineapple peel liquid organic fertilizer and measured plant height, leaf number, plant weight, and root development (Kuswardina & Abror, 2023). These findings indicate that this material can be used to design experiments linking treatment variation to changes in vegetative plant growth.

In plant physiology practicum activities, experiments using pineapple peel liquid organic fertilizer allow students to observe plant height, stem diameter, number of leaves, leaf width or area, root development, and plant biomass. These parameters can be used to explain the relationship between nutrient availability and the processes of cell division, elongation, and differentiation. Variation in concentration also enables students to analyze the fact that plant physiological responses do not always increase linearly. Concentrations that are too low may not provide adequate nutrients, whereas overly concentrated solutions may alter the chemical conditions of the growing medium and inhibit water or nutrient uptake. Such activities can direct students not only to record results but also to explain the biological mechanisms underlying observed response patterns.

Integrating pineapple peel liquid organic fertilizer into a practicum guide also has pedagogical and environmental value. Students can learn to make quantitative measurements, control variables, compare treatments, present data in tables or graphs, and draw conclusions based on observations. At the same time, they are introduced to the utilization of agro-industrial waste and the application of sustainability principles in biological experimentation. Research-based practicum experiences can increase students' engagement in the scientific process because they work with real biological objects, encounter variation in results, and must interpret data critically (Schnell et al., 2021; Wulandari, 2021).

Despite its strong learning potential, a practicum guide should not be used directly without systematic evaluation. Conceptual errors, misaligned objectives, ambiguous procedures, inaccurate quantities of materials, incomplete safety instructions, and irrelevant analytical questions can reduce the quality of practicum activities. The development of a practicum guide should therefore evaluate content accuracy, activity relevance, clarity of instructions, organization of material, language use, procedural feasibility, alignment with learning outcomes, and laboratory safety before the product proceeds to user testing (Arif & Maya, 2019; Thahir et al., 2021).

Content validity indicates the extent to which the components of a practicum guide represent the competencies, concepts, and activities that should be facilitated. Expert ratings can be converted into quantitative evidence of the degree of agreement regarding the relevance of each item. One index commonly used for this purpose is Aiken's V, whose coefficient ranges from 0 to 1; values closer to 1 indicate stronger expert agreement (Aiken, 1985). Because estimates based on small expert panels involve greater uncertainty, interpretation of the coefficient can be strengthened by reporting confidence intervals for Aiken's V (Penfield & Giacobbi, 2004).

Aiken's V is appropriate for evaluating components of a practicum guide, such as alignment of objectives with learning outcomes, accuracy of plant physiology content, clarity of procedures for producing liquid organic fertilizer, appropriateness of concentration variations, suitability of tools and materials, experimental safety, suitability of observation tables, quality of analytical questions, language, and presentation. Item-level analysis makes it possible to identify more specifically which components have achieved strong agreement and which still require revision. In this study, revision decisions were based not only on the magnitude of the coefficient but also on the 95% confidence intervals and validators' qualitative comments (Aiken, 1985; Penfield & Giacobbi, 2004).

Several previous studies have developed inquiry-based or learning-by-research plant physiology practicum guides and reported that the resulting products met validity criteria and could be used in practicum activities (Arif & Maya, 2019; Wulandari, 2021; Thahir et al., 2021). Other studies have also developed and validated laboratory manuals in biology and science, emphasizing content accuracy, instructional clarity, scientific skills, and laboratory safety (Arif & Maya, 2019; Thahir et al., 2021). However, the development of a plant physiology practicum guide that specifically uses pineapple peel liquid organic fertilizer as an experimental context and analyzes the validity of each component using Aiken's V remains limited.

The novelty of this study lies in integrating plant physiology concepts, utilization of pineapple peel waste, plant growth experiments, and quantitative content-validity analysis. The developed guide is intended not only to help students carry out practicum procedures but also to facilitate observation of plant responses to different fertilizer concentrations, analysis of growth data, evidence-based reasoning, and understanding of organic waste management. Therefore, this study aimed to develop a plant physiology practicum guide using pineapple peel liquid organic fertilizer and to analyze its content validity using Aiken's V. The study was expected to produce a guide that is scientifically accurate, procedurally clear, feasible to implement, safe to use, and relevant to plant physiology instruction and education for sustainability.

RESEARCH METHOD

Research Design

This study employed a research and development approach using the 4D model, which consists of the Define, Design, Develop, and Disseminate stages. Implementation was limited to the Develop stage, specifically expert validation and product revision. Field testing and the Disseminate stage were not conducted because the study focused on obtaining evidence of the practicum guide's content validity before broader implementation in instruction.

The product developed was a plant physiology practicum guide using pineapple peel liquid organic fertilizer. The guide was designed to facilitate learning about plant mineral nutrition, vegetative growth, organic waste utilization, experimental design, measurement of growth parameters, data presentation, and interpretation of plant physiological responses.

Development Procedure

The development procedure comprised the Define, Design, and Develop stages. The Disseminate stage was not implemented in this study.

Define Stage

The Define stage was operationalized through target-user analysis, learning-document analysis, concept analysis, and practicum-task analysis. The target users were students enrolled in Plant Physiology. The document analysis mapped learning outcomes, the structure of practicum activities, needs for work instructions and data recording, and safety requirements. The needs analysis at this stage was qualitative-descriptive and was used to identify the main requirements for developing the practicum guide.

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The mapping identified four primary product needs: (1) a guide linking the concepts of mineral nutrition and vegetative growth with measurable parameters; (2) a practicum context based on local resources and organic waste management; (3) systematic experimental procedures, including the production of liquid organic fertilizer, determination of concentrations, preparation of test plants, and measurement; and (4) data-recording and analysis formats that help students present graphs and draw evidence-based conclusions. The concept analysis covered mineral nutrition, growth and development, cell division and elongation, fermentation of organic materials, liquid organic fertilizer, utilization of pineapple peel waste, solution concentration, and vegetative plant responses.

Design Stage

The Design stage produced the initial draft of the practicum guide. The draft included a cover and product identity, preface, table of contents, learning outcomes, practicum objectives, instructions for use, rules and safety guidelines, theoretical background, tools and materials, procedures for producing pineapple peel liquid organic fertilizer, treatment design, observation procedures, data-recording tables, guidance for descriptive analysis, discussion questions, reflection, conclusions, and references. This structure constituted the design output that was subsequently validated during the Develop stage.

The experimental design in the draft used four concentrations of pineapple peel liquid organic fertilizer: 0 mL L^{-1} as the control, 10 mL L^{-1}, 20 mL L^{-1}, and 30 mL L^{-1}. The observed growth parameters included plant height, stem diameter, number of leaves, and leaf width. At the same stage, a validation sheet was developed to map three main aspects—content, language, and presentation—onto operational indicators corresponding to the product components.

Develop Stage

The Develop stage was limited to expert validation and product revision. The initial draft of the guide was purposively assigned to three validators. The three-member expert panel represented complementary perspectives required for the product: expertise in plant physiology, biology teaching/practicum activities, and the development and evaluation of instructional materials. Each validator independently assessed all items and provided comments and suggestions for improvement. The limited panel size was taken into account in interpreting Aiken's V by reporting 95% confidence intervals.

Validation scores were analyzed using Aiken's V to determine the level of expert agreement regarding the relevance of each item. Validator comments were used to improve conceptual accuracy, procedural clarity, language, readability, organization, visual elements, and safety instructions. The revised product constituted the final output of this study. Therefore, the results provide evidence only of content validity and do not demonstrate the practicality or effectiveness of the guide in instruction.

Validators and Validation Instrument

Validation involved three validators with at least a master's degree in a relevant field and experience in biology/plant physiology teaching, practicum-based learning, and/or the development and evaluation of instructional materials. Their profiles were reported functionally according to the basis for panel selection. Instrument indicators were derived from the guide components to be evaluated: alignment of objectives, content, procedures, parameters, and analytical questions (content); accuracy and readability of wording (language); and consistency and clarity of visual presentation (presentation). The instrument used a four-point scale: 1 = not relevant, 2 = somewhat relevant, 3 = relevant, and 4 = highly relevant. These relevance ratings were then analyzed using Aiken's V (Aiken, 1985).

Table 1. Functional profiles of the validators

Validator	Primary area of expertise	Relevant experience	Validation focus
V1	Plant physiology	Teaching and assessment of plant physiology/ practicum content	Accuracy of concepts, objectives, treatments, and parameters
V2	Biology education and practicum	Teaching and evaluation of biology practicum activities	Sequence of procedures, suitability for users, and language
V3	Instructional-material development/evaluation	Development and evaluation of instructional materials/ practicum guides	Presentation, readability, layout, and visual elements

Table 2. Aspects and indicators used to validate the practicum guide

No.	Aspect	Assessment indicators
1	Content	Alignment of objectives with learning outcomes; accuracy of plant physiology concepts; accuracy of pineapple peel LOF content; suitability of tools and materials; sequence of procedures; suitability of parameters; and relevance of analytical questions.
2	Language	Use of standard language; sentence effectiveness; clarity of instructions; consistency of scientific terminology; suitability of language for university students; accuracy of spelling; and readability.
3	Presentation	Cover design; layout consistency; font type and size; clarity of tables; suitability of illustrations; color harmony; and consistency of numbering and organization.

Data Collection Technique

Data were collected through validators' assessments of the draft practicum guide. Each validator received the product, a validation sheet, completion instructions, the rating scale, and space for comments. Quantitative data consisted of each validator's item-level scores, which were used to calculate Aiken's V. Qualitative data consisted of validator comments and suggestions and were used as the basis for product revision.

Data Analysis Technique

Aiken's V was calculated for each item using the equation $V = \Sigma s/[n(c - 1)]$, where $s = r - l_0$. In this equation, r is the score assigned by a validator, l_0 is the lowest possible score, n is the number of validators, and c is the number of rating categories. This study used three validators and four score categories; therefore, the denominator for each item was $3(4 - 1) = 9$.

$$\mathbf{V = \Sigma(r - 1) / 9}$$

Aiken's V ranges from 0 to 1, with values closer to 1 indicating stronger expert agreement (Aiken, 1985). This study did not use $V \geq 0.80$ as a universal critical value. Because

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the panel consisted of only three validators using four rating categories, each item-level coefficient was accompanied by a 95% confidence interval based on the score confidence interval for Aiken's V developed by Penfield and Giacobbi (2004). Mean values at the aspect and overall levels were used as descriptive summaries, while revision decisions considered the magnitude of V, the width of the confidence interval, and validators' qualitative comments. With n = 3 and c = 4, relatively wide intervals were treated as a limitation in estimation precision rather than as a basis for claiming that the product was practical or effective.

Table 3. Principles for interpreting Aiken's V coefficients

Interpretation component	Basis	Reporting decision
Aiken's V coefficient	Range 0–1; values closer to 1 indicate stronger expert agreement (Aiken, 1985)	Reported for each item and as a descriptive mean
95% confidence interval	Score confidence interval for Aiken's V (Penfield & Giacobbi, 2004)	Reported for each item; CI width is considered because n = 3
Qualitative comments	Validator feedback on content, language, and presentation	Used as a basis for revision even when V is relatively high

RESULT AND DISCUSSION

Content Validation Results

The content aspect was evaluated using seven items covering alignment of objectives, accuracy of plant physiology concepts, pineapple peel liquid organic fertilizer content, tools and materials, practicum procedures, observation parameters, and analytical questions. The V1–V3 scores in Table 4 show the ratings assigned by each validator. Aiken's V coefficients and 95% confidence intervals were calculated from these scores.

Table 4. Aiken's V results and 95% confidence intervals for the content aspect

Code	Assessment indicator	V1	V2	V3	V	95% CI
I1	Alignment of practicum objectives with learning outcomes	4	3	3	0.778	0.453–0.937
I2	Accuracy of plant physiology concepts	3	4	3	0.778	0.453–0.937
I3	Accuracy of pineapple peel liquid organic fertilizer content	3	3	4	0.778	0.453–0.937
I4	Suitability of practicum tools and materials	4	3	3	0.778	0.453–0.937
I5	Accuracy and sequence of practicum procedures	3	4	3	0.778	0.453–0.937
I6	Suitability of vegetative growth parameters	3	3	4	0.778	0.453–0.937
I7	Suitability of analytical questions and discussion activities	4	4	3	0.889	0.565–0.980
Mean Aiken's V					0.794	—

The content aspect obtained a mean Aiken's V of 0.794, equivalent to 79.4% descriptively. Six items obtained V = 0.778 (95% CI: 0.453–0.937), and one item obtained V = 0.889 (95% CI: 0.565–0.980). The relatively wide intervals reflect estimation uncertainty resulting from the panel of only three validators. Therefore, the content results were interpreted together with validator comments and used as the basis for revision before the product proceeded to practicality testing.

Language Validation Results

The language aspect covered the use of standard Indonesian, sentence effectiveness, clarity of instructions, consistency of scientific terminology, suitability of language for university students, spelling, and readability. The results are presented in Table 5.

Table 5. Aiken's V results and 95% confidence intervals for the language aspect

Code	Assessment indicator	V1	V2	V3	V	95% CI
B1	Appropriate use of standard Indonesian	4	4	4	1.000	0.701–1.000
B2	Effectiveness of sentence structure	4	4	4	1.000	0.701–1.000
B3	Clarity of imperative sentences in procedures	4	4	4	1.000	0.701–1.000
B4	Consistency in the use of scientific terminology	4	4	4	1.000	0.701–1.000
B5	Suitability of language for university students	4	4	3	0.889	0.565–0.980
B6	Accuracy of spelling and punctuation	4	3	4	0.889	0.565–0.980
B7	Readability and communicative quality of language	3	4	4	0.889	0.565–0.980
	Mean Aiken's V				0.952	—

The language aspect obtained a mean Aiken's V of 0.952, equivalent to 95.2% descriptively. Four items obtained V = 1.000 (95% CI: 0.701–1.000), whereas three items obtained V = 0.889 (95% CI: 0.565–0.980). These results indicate the strongest expert agreement for the language aspect compared with the other two aspects, although minor editorial revisions were still made in response to validator comments.

Presentation Validation Results

The presentation aspect was assessed through cover design, layout consistency, font type and size, clarity of observation tables, suitability of illustrations, color harmony, and consistency of numbering and organization. The results are presented in Table 6.

Table 6. Aiken's V results and 95% confidence intervals for the presentation aspect

Code	Assessment indicator	V1	V2	V3	V	95% CI
T1	Suitability of cover design to the guide content	4	3	3	0.778	0.453–0.937
T2	Consistency of layout across sections	3	4	3	0.778	0.453–0.937
T3	Suitability of font type and size	3	3	4	0.778	0.453–0.937
T4	Clarity of observation-table presentation	4	3	3	0.778	0.453–0.937

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Code	Assessment indicator	V1	V2	V3	V	95% CI
T5	Suitability of supporting images or illustrations	3	4	3	0.778	0.453–0.937
T6	Harmony of colors and visual elements	3	3	3	0.667	0.354–0.879
T7	Consistency of numbering and organization	3	3	3	0.667	0.354–0.879
	Mean Aiken's V				0.746	—

The presentation aspect obtained a mean Aiken's V of 0.746, equivalent to 74.6% descriptively. Five items obtained V = 0.778 (95% CI: 0.453–0.937), whereas color harmony and numbering consistency obtained V = 0.667 (95% CI: 0.354–0.879). These values and intervals, together with validator comments, identified presentation as the primary revision priority, particularly with regard to color, layout, illustrations, and organization.

Summary of Practicum Guide Validity

Table 7. Summary of practicum guide validation results

Component	Number of items	Aiken's V	Percentage	Descriptive interpretation	Decision
Content	7	0.794	79.4%	Relatively strong agreement; estimation uncertainty remains	Revise content before further testing
Language	7	0.952	95.2%	Strongest expert agreement	Minor editorial revision
Presentation	7	0.746	74.6%	Moderately strong agreement; priority for improvement	Revise color, layout, illustrations, and numbering
Overall	21	0.831	83.1%	Adequate descriptive evidence of content validity	Proceed to practicality and effectiveness testing after revision

Overall, the practicum guide obtained a mean Aiken's V of 0.831, equivalent to 83.1%. This value was treated as a descriptive summary rather than as sole evidence that the product was ready for use. Considering the item-level confidence intervals and qualitative comments, the validation results indicate that the guide has evidence of content validity based on expert judgment and should be refined before proceeding to practicality and effectiveness testing.

Product Revision Based on Validation Results

Product revisions integrated quantitative information from Aiken's V, 95% confidence intervals, and validators' qualitative suggestions. For the content aspect, revisions focused on strengthening the alignment between objectives and procedures, refining conceptual explanations, and simplifying procedural steps. For the language aspect, revisions addressed spelling, punctuation, sentence effectiveness, and terminological consistency. For the

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presentation aspect, revisions focused on color harmony, layout consistency, the instructional function of illustrations, and numbering and organization. A summary of the changes before and after revision is presented in Table 8 as evidence of implementation of the Develop stage.

Table 8. Summary of product revisions based on validator comments

Aspect	Before revision/validator finding	Revision made	After revision
Content	The alignment among objectives, concepts, and procedures was not fully explicit	Aligned objectives and procedures, refined concepts, and simplified procedural steps	The content flow is more consistent and easier to follow
Language	Some sections still required editing of spelling, punctuation, and terminology	Edited wording and standardized terminology and units	The language is more concise, consistent, and communicative
Color	Color harmony received the lowest score within the presentation aspect	Reduced color variation and harmonized visual elements	The visual palette is more consistent and does not interfere with readability
Layout	The consistency of heading positions, tables, and spacing between sections needed improvement	Standardized heading hierarchy, spacing, and element placement	The layout is more consistent across sections
Illustrations	Illustrations needed to better support the procedures and observed objects	Clarified the function of illustrations for fermentation, LOF application, and measurement	The illustrations are more relevant to the practicum steps
Numbering	Numbering and presentation organization were inconsistent	Standardized numbering of sections, steps, tables, and activity sequences	The organization and navigation of sections are clearer

Discussion

The validation results showed that the plant physiology practicum guide using pineapple peel liquid organic fertilizer achieved different levels of expert agreement for the content, language, and presentation aspects. The overall mean Aiken's V of 0.831 provides descriptive evidence of adequate content validity. However, because the panel consisted of only three validators, interpretation was not based on a single categorical cutoff; instead, it also considered the 95% confidence interval for each item and qualitative comments. This approach made revision decisions more proportionate to the limitations imposed by the small panel size (Aiken, 1985; Penfield & Giacobbi, 2004).

These findings are consistent with Arifin et al. (2024), who developed learning materials using the 4D model through the Develop stage and analyzed their validity using Aiken's V. Their study showed that expert judgment is an important step for ensuring the suitability of a product's content and construct before it is used in instruction. The similarity in approach supports the appropriateness of using Aiken's V in the present study to convert relevance ratings from several validators into quantitative evidence of content validity. Nevertheless, expert validation should still be accompanied by revisions based on qualitative comments because numerical values do not necessarily capture all conceptual, procedural, and visual weaknesses of a product.

Validity of the Content Aspect

The content aspect obtained a mean Aiken's V of 0.794. Descriptively, this value indicates relatively strong expert agreement, although the item-level confidence intervals remained wide because of the limited number of validators. Therefore, the content assessment was not treated as a final decision regarding suitability for use but rather as evidence of content validity to be combined with validator suggestions for improving objectives, concepts, procedures, parameters, and analytical questions.

Six indicators in the content aspect obtained the same value, 0.778. This similarity indicates relatively consistent ratings across validators regarding the alignment of objectives, accuracy of concepts, liquid organic fertilizer content, tools and materials, procedures, and vegetative growth parameters. The value also indicates that content weaknesses were not concentrated in a single component but were distributed across several sections that required refinement. Revision therefore needed to address not only one section but also the alignment of practicum objectives with activities, strengthening of the theoretical basis, accuracy of treatment units and concentrations, clarity of procedural steps, and consistency between observed parameters and data-recording tables.

The present findings can be compared with those of Arifin et al. (2022) on a research-based Applied Biology module. Their study reported a content-feasibility percentage of 85.41%, whereas the content aspect of the practicum guide in the present study reached 79.4%. This difference indicates that the current guide requires more substantial refinement, particularly in conceptual accuracy and clarity of experimental procedures. In Arifin et al. (2022), content feasibility was assessed based on completeness, depth and accuracy of material, currency of information, ability to stimulate curiosity, life skills, and contextual relevance. These components can guide revisions so that the practicum guide not only presents procedural steps but also provides adequate scientific explanations and connects practicum activities with environmental issues and organic waste utilization.

The analytical-questions and discussion-activities indicator obtained the highest value within the content aspect, namely 0.889. This finding indicates that the questions were considered capable of directing students to connect observational data with plant physiology concepts. Analytical questions are important because practicum activities should not end with measurements of plant height, stem diameter, number of leaves, and leaf width. Students also need to interpret growth patterns, compare responses across concentrations, explain possible nutrient functions, and identify other factors that may influence the results. Thus, the high value for this component suggests that the guide has the potential to support inquiry-based learning and evidence-based reasoning.

Nevertheless, analytical questions should remain aligned with the type of data analysis used. If practicum data are analyzed only descriptively, the questions should not direct students to conclude that statistically significant effects or proven causal relationships exist. More appropriate questions should focus on identifying trends, comparing mean values, explaining possible physiological mechanisms, and evaluating experimental limitations. Such alignment is important for maintaining scientific accuracy and preventing students from drawing conclusions that go beyond the data obtained.

Validity of the Language Aspect

The language aspect obtained the highest mean Aiken's V, namely 0.952. Four indicators received the maximum value of 1.000: appropriate use of standard Indonesian, effective sentence structure, clarity of imperative sentences, and consistency of scientific terminology. These results indicate complete agreement among the three validators that the main language components had been appropriately formulated. Clear language is particularly important in a practicum guide because misunderstanding a single instruction can lead to differences in solution volume, procedural sequence, treatment duration, or measurement technique.

The maximum score for clarity of imperative sentences indicates that the practicum procedures generally used operational wording that students could follow. Effective instructions should use specific verbs such as weigh, measure, mix, filter, apply, observe, and record. Operational wording reduces the likelihood of differing interpretations and helps maintain consistency in practicum implementation across groups.

The language-aspect result in this study was higher than the 83.33% language-validation result reported for the research-based module developed by Arifin et al. (2022). In that study, language assessment covered suitability for student development, communicativeness, conciseness, logical flow of ideas, adherence to Indonesian language conventions, and consistency in the use of terms and symbols. This comparison indicates that the developed practicum guide has strengths in clarity and consistency of wording. Nevertheless, scores of 0.889 for suitability of language to university students, spelling and punctuation, and readability indicate that final editing is still necessary.

Language editing can focus on shortening overly long sentences, ensuring consistency in the notation of units, standardizing the term liquid organic fertilizer and its abbreviation, italicizing scientific names, and using the terms "practicum guide" and "practicum instructions" consistently. In addition, safety instructions should be written directly and unambiguously. Technical terms such as fermentation, control variable, vegetative growth, stem diameter, and solution concentration should also be briefly explained when first introduced.

Validity of the Presentation Aspect

The presentation aspect obtained a mean Aiken's V of 0.746 and was the lowest-scoring component. Descriptively, this result indicates that the presentation elements received expert support but still require improvement. This interpretation is reinforced by V = 0.667 for color harmony and numbering consistency and by the wide confidence intervals; therefore, visual revision remains a priority.

Cover design, layout, font type and size, observation tables, and illustrations each obtained a value of 0.778. These values indicate that the components can be retained but should be improved. The cover should directly represent the context of plant physiology, pineapple peel waste, liquid organic fertilizer, and the test plants. The layout of each activity should use a consistent structure, for example objectives, theoretical background, tools and materials, procedures, observations, analysis, and conclusions. Observation tables should also provide sufficient space to record data by time point, treatment, and replicate.

Color harmony and visual elements, together with numbering consistency, obtained the lowest value, 0.667. This finding indicates that the main presentation problems concerned design harmony and document navigation. Excessive use of colors, inconsistent heading styles, differences in font size, or inconsistent numbering can reduce readability and create the impression that the product has not been thoroughly edited. Revision should therefore establish a single heading hierarchy, a consistent numbering pattern, an easily readable font, proportionate font sizes, and limited but consistent use of color.

The importance of attractive media presentation is also evident in Arifin's (2024) study on a virtual aquatic ecosystem learning medium supported by 3D Pageflip. The study emphasized that learning media should present material in an engaging and understandable manner and use visual and interactive elements to support the learning experience. The product received practicality responses of 89.32% from teachers and 86.04% from students. Although the product differed from a printed practicum guide, the findings indicate that clear presentation and ease of use are important components of users' acceptance of instructional materials.

The presentation-aspect result was also lower than the 84.09% presentation score reported for the module developed by Arifin et al. (2022). This comparison reinforces the need to revise presentation techniques, supporting elements, and the organizational consistency of the guide. Illustrations should not only be visually appealing but should also serve instructional functions, such as clarifying the form of the fermentation container, procedures for mixing materials, fertilizer-application techniques, the point at which stem diameter is measured, and the method for measuring leaf width.

Overall Validity of the Practicum Guide

The overall Aiken's V coefficient of 0.831 indicates that the practicum guide has evidence of content validity based on expert judgment. This value was not used to claim that the product was ready for immediate use because practicality and effectiveness had not yet been tested. After revisions to the content, language, and presentation, the product can proceed to practicality and effectiveness testing.

The main strength of the guide lies in its language aspect, whereas the priority areas for improvement are presentation and several content components. This pattern suggests that students are likely to understand the instructions provided, but their experience in using the guide may still be affected by a visual design and organization that are not yet fully consistent. Therefore, product revision should be targeted rather than limited to spelling corrections. Improvements should address the relationship between objectives and procedures, depth of plant physiology concepts, accuracy of parameters, safety, consistency of tables, numbering, illustrations, and layout.

The results also support the use of the 4D model when development is limited to the Develop stage. Arifin et al. (2024) used the Define, Design, and Develop stages to produce learning materials that were validated using Aiken's V before practicality testing. These stages demonstrate that expert validation functions as an initial screening process for identifying product weaknesses before users are involved in instructional trials.

However, evidence of content validity based on expert judgment does not demonstrate that the practicum guide is easy to use or effective in improving student understanding. The present study provides evidence only of content suitability based on expert assessment. Therefore, future research should conduct small-group trials and field testing to evaluate readability, practicality, procedural implementation, student responses, time requirements, and effectiveness. This stage is important because a product judged valid by experts may still encounter difficulties in direct use, such as problems obtaining materials, unclear observation tables, long fermentation periods, or differences in students' measurement skills.

Overall, the mean Aiken's V of 0.831 provides an adequate basis of content validity for continuing the development process. The main strength lies in the language aspect, whereas

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the primary revision priorities concern presentation and several content components. These results should be interpreted within the limitations of a study involving only three validators and no user testing; accordingly, the conclusions are restricted to content validity and the product's readiness to proceed to the next stage of evaluation.

CONCLUSION

The plant physiology practicum guide using pineapple peel liquid organic fertilizer was developed through the Define, Design, and Develop stages of the 4D model. Validation by three experts yielded mean Aiken's V values of 0.794 for content, 0.952 for language, 0.746 for presentation, and 0.831 overall. Item-level analyses included 95% confidence intervals to account for the limitation of a panel consisting of only three validators, while qualitative comments were used as the basis for product revision. The findings indicate that the guide has evidence of content validity based on expert judgment, with priority improvements involving color harmony, layout, illustrations, numbering, and several content components. Because the study did not assess user readability, practicality, procedural implementation, or instructional effectiveness, the product is not claimed to be ready for immediate use; however, after revision, it is suitable for further practicality and effectiveness testing.

RECOMMENDATIONS

Future research should continue the development process through small-group trials and field testing to evaluate readability, practicality, procedural implementation, time requirements, and responses from students and lecturers. The effectiveness of the guide should also be examined using an experimental design to determine its contribution to conceptual understanding, science process skills, data-analysis ability, and students' awareness of organic waste utilization. Once validity, practicality, and effectiveness have been established, the product can proceed to the Disseminate stage and be used more broadly in plant physiology practicum activities.

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