



Validity of STEM-Based IPAS E-Worksheets for Elementary School Students

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ABSTRACT

Purpose of the study: This study aimed to determine the validity of a STEM-based Electronic Student Worksheet for elementary school science learning (IPAS) based on material suitability, language clarity and readability, display and navigation quality, and the integration of Science, Technology, Engineering, and Mathematics components.

Methodology: This study employed a research and development approach focusing on the expert validation stage. The STEM-based Electronic Student Worksheet was assessed by two validators using a five-point Likert scale. The validation instrument covered four aspects, namely material, language, display, and STEM integration. The validity data were analyzed quantitatively using Aiken's V coefficient.

Main Findings: The validation results showed Aiken's V values of 0.875 for material, 0.750 for language, 0.875 for display, and 0.875 for STEM integration. The overall average Aiken's V score was 0.844 and was categorized as very valid. These results indicate that the developed E-worksheet has fulfilled the validity criteria in terms of content suitability, language, visual display, navigation, and STEM integration, although the language aspect still requires refinement.

Novelty/Originality of this study: This study offers a STEM-based E-worksheet validation framework for elementary IPAS learning by integrating assessment of content suitability, language, digital display, navigation, and STEM components. The developed E-LKPD is designed to connect science concepts with technology, engineering activities, and mathematical reasoning in a contextual and interactive learning environment for elementary school students.

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1. INTRODUCTION

The development of digital teaching materials needs to consider the relationship between learning content, modes of presentation, and the activities undertaken by students. Digitalization is not merely the transfer of text from printed media to a screen, but also an opportunity to organize learning materials and activities in a more structured and purposeful manner [1]; [2]. The use of e-modules that integrate learning materials, illustrations, and exercises, while also positioning expert evaluation as an important part of product development [3]; [4]. This framework provides a basis for designing the evaluation of digital teaching materials before they are implemented in the learning process [5].

In this study, the electronic student worksheet (E-Worksheet) is positioned as a teaching material that connects IPAS content with learning activities, questions, result recording, and reflection. This structure represents the operational design of the proposed product rather than a description of an implementation that has already been tested. The suitability of the E-Worksheet needs to be examined in relation to the learning objectives and learning outcomes for the targeted grade or phase [6]. An attractive presentation alone is insufficient if the questions do not guide students toward the intended competencies or if the activity instructions are difficult to understand [7]; [8].

The STEM approach incorporated into the proposed product includes science, technology, engineering, and mathematics [9]; [10]; [11]. Its integration is directed toward connecting the four components within a coherent sequence of learning activities, rather than merely presenting STEM-related terms or icon [12]; [13]; [14]; [15]s. Operationally, the science component can be represented through observation and explanation of phenomena; technology through the use of tools or media; engineering through the design and testing of solutions; and mathematics through measurement, calculation, or data interpretation [16]; [17]. Therefore, the assessment of STEM integration should examine the actual learning activities provided in the E-Worksheet [18]; [19]; [11]; [20]. [3]; [5] developed an e-module using the Plomp model. The study reported an average Aiken's V score of 0.728, categorized as valid, and evaluated several aspects, including material, language, and display quality. This reference illustrates how the validation of digital teaching materials can be organized. However, the context differs from that of a STEM-based IPAS E-Worksheet for elementary school students; therefore, its validity results cannot be directly transferred to claim the validity of the product developed in this study. Based on these differences, the research problem is formulated as the need to obtain documented expert judgments on four product aspects: material, language, display, and STEM integration. The focus is to establish an evaluation basis that enables researchers to determine whether the material is aligned with the learning outcomes, the language is understandable, the design supports usability, and the activities adequately represent STEM integration. This study aims to describe the validity of a STEM-based IPAS E-Worksheet through assessments conducted by two validators using the Aiken's V index. The proposed contribution lies in integrating these four aspects into the initial evaluation of a digital learning product for elementary school students. This contribution is contextual in nature and is not intended to claim that such an approach has never been investigated before.

2. RESEARCH METHOD

The research design is a development study that adapts the stages of preliminary investigation, prototype development, and evaluation from Plomp's model [3]. The report focuses on expert evaluation of the prototype; therefore, it does not include testing of practicality or learning effectiveness. In the initial investigation phase, planned activities include identifying the target class or phase, selecting IPAS topics, mapping learning outcomes, and determining STEM activity needs. The prototype phase is directed toward the development of materials, instructions, activities, questions, and the E-LKPD interface. The expert evaluation phase is planned to obtain scores and improvement suggestions before the product is refined and, in follow-up research, tested with users. The research subject is a STEM-based IPAS E-LKPD for fifth grade on the topic of Energy Sources. The research location and time were specified by SDS Bani Rauf. The proposed instrument is an expert validation sheet with a 1–5 scale and a comment column. The proposed assessment anchors to clarify the instrument are: 1 = strongly disagree, 2 = disagree, 3 = somewhat agree, 4 = agree, and 5 = strongly agree..

Table 1. Validation Aspects and Indicators for the STEM-Based IPAS E-LKPD

Aspect	Indicator
Content	Alignment with IPAS learning outcomes
Language	Clarity and readability
Display	Design and navigation
STEM	Integration of STEM components

The planned data collection procedure begins with submitting the E-LKPD prototype, learning objectives, learning outcome mapping, and assessment instruments to both validators. Each validator scores the materials independently and notes which parts of the product need improvement. Scores are then summarized by indicator, while comments are grouped by content, language, presentation, and STEM. Product revisions are based on actual issues identified, not merely on average categories. If revisions substantially alter the content or activities, a re-evaluation may be planned and reported as a separate round. Quantitative analysis uses Aiken's V index. For each indicator, the validator's score is subtracted from the lowest score on the scale. These differences are summed and divided by the product of the number of validators and the scale range, as shown in Equation (1).

$$V = \frac{\sum(r - l_0)}{n(c - 1)} \quad (1)$$

In Equation (1), V is the index for a single indicator; r is the score of each validator; l_0 is the lowest score, which is 1; n is the number of validators, which is 2; and c is the number of scale categories, which is 5. On this 1–5 scale, c is also equal to the highest score. The value $s = r - l_0$ is the difference from the minimum score. The denominator for each indicator is $2(5 - 1) = 8$. The overall average is calculated from the four indices with equal weights because each aspect is represented by one indicator.

Table 2. Criteria for interpreting Aiken's V

Interval V	Kategori
$0,81 < V \leq 1,00$	Highly valid
$0,61 < V \leq 0,80$	Valid
$0,41 < V \leq 0,60$	Moderately valid
$0,21 < V \leq 0,40$	Less valid
$0,00 < V \leq 0,20$	Not valid

3. RESULTS AND DISCUSSION

3.1 Results of the E-Worksheet Development

The resulting product is a STEM-based IPAS E-Worksheet that includes instructions for use, learning outcomes, content, STEM activities, interactive worksheets, assessments, and student reflections..

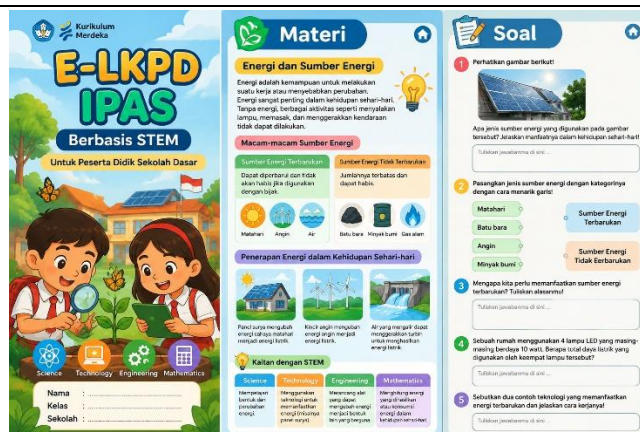


Figure 1. STEM-Based E-LKPD Display

3.2. Expert Validation Results

Validation was conducted by material experts and media experts to determine the feasibility of the developed product. The assessment covered the aspects of material, language, display, and STEM integration.

Table 3. E-Worksheet Validation Results Based on Aiken's V

Aspect	Indicator	Validator 1	Validator 2	Aiken's V	Category
Material	Suitability with IPAS Learning Outcomes	4	5	0,80	Valid
Language	Clarity and Readability	4	4	0,75	Valid
Display	Design and Navigation	5	4	0,80	Valid
STEM	Integration of STEM Components	4	5	0,80	Valid
Overall Score				0,79	Valid

Table 3 presents the scores from two validators and the recalculated Aiken's V values. The scores used were 4 and 5 for the material aspect, 4 and 4 for the language aspect, 5 and 4 for the display aspect, and 4 and 5 for the STEM aspect..

Tabel 4. Validation Results of the E-Worksheet by Two Validators

Aspek	Validator 1	Validator 2	Σs	Aiken's V	Kategori
Material	4	5	7	0,875	Very valid
Language	4	4	6	0,750	Valid
Display	5	4	7	0,875	Very valid
STEM	4	5	7	0,875	Very valid
Average	-	-	-	0,844	Very valid

The Aiken's V indices for the material, display, and STEM aspects were 0.875, while the language aspect obtained a value of 0.750. The average of the four indices was 0.84375, or 0.844 when rounded to three decimal places. Based on the adopted validity criteria, the material, display, and STEM aspects were categorized as very valid, while the language aspect was categorized as valid. Overall, the E-Worksheet was categorized as very valid. The category determination was based on the original values before rounding in order to avoid possible shifts at the category boundaries. For example, in the material aspect, scores of 4 and 5 produced differences of 3 and 4 from the minimum score. The total difference was 7; therefore, the Aiken's V index was $7/8 = 0.875$. For the language aspect, scores of 4 and 4

produced a total difference of 6, resulting in an Aiken's V index of $6/8 = 0.750$. The average of the four indices is shown in Equation (2).

$$\text{Rerata V} = \frac{0,875 + 0,750 + 0,875 + 0,875}{4} = 0,84375 \approx 0,844 \quad (2)$$

With two validators and a 1–5 scale, a one-point change in one score changes the indicator index by $1/8$ or 0.125 . Therefore, differences in validity categories should be interpreted together with the original scores and expert comments rather than solely on the basis of the average value. The results above illustrate how the four aspects of the E-Worksheet can be reported within a single validation framework. For the material aspect, the value of 0.875 represents scores of 4 and 5 regarding its suitability with the IPAS learning outcomes. Supporting evidence should include alignment among the learning outcomes, activity objectives, learning content, and assessment questions. This examination is important to ensure that the validity category is not based only on the validators' general impressions of the topic. The language aspect obtained the lowest score, with an Aiken's V value of 0.750 , although it remained within the valid category. The language component can therefore be further refined by improving the clarity of instructions, sentence length, consistency of terminology, and the avoidance of ambiguous expressions. For the display aspect, the value of 0.875 reflects a high level of validity related to font readability, layout organization, clarity of illustrations, and consistency of navigation. Likewise, the STEM aspect obtained a value of 0.875 , indicating a high level of validity in the integration of science, technology, engineering, and mathematics components within the learning activities.

3.5 Discussion

Development of a STEM-based IPAS E-Worksheet needs to consider the interrelationship among material suitability, language clarity, display quality, and the integration of learning activities. Validity is required to assess the appropriateness of the product design, while practicality and effectiveness require evidence from actual use and the achievement of learning objectives [21]; [3]. This distinction is consistent with the reference study, which employed expert validation, user response questionnaires, and pre-test and post-test assessments to evaluate different dimensions of product quality [22]. Conceptually, STEM integration in the E-Worksheet provides opportunities for students to connect IPAS concepts with real-life problems through observation, design, testing, and reflection activities. The science component is directed toward understanding phenomena, technology toward the use of tools and media, engineering toward the development of solutions, and mathematics toward measurement and data processing [23]; [24]. The interconnection among these components has the potential to make learning more meaningful because students do not merely study concepts, but also consider their application in real-life contexts. Activities that provide multiple solution alternatives and require students to justify their answers based on observation can also support the development of creativity and critical thinking skills [25]; [26].

The use of digital technology through the E-Worksheet can support more flexible and interactive learning by providing learning materials, activity instructions, illustrations, and spaces for student responses [27]; [28]; [29]. However, its flexibility still depends on the availability of devices, access to learning materials, and internet connectivity when required. Practicality should therefore not be assessed only from visual attractiveness, but also from readability, ease of navigation, clarity of instructions, and the appropriateness of the time required to complete activities. The reference article [3]; [30] showed that students still experienced difficulties in understanding the e-module even though the overall assessment was positive, which indicates that the structure and visual presentation need to be simplified when necessary. To support IPAS learning within the Merdeka Curriculum, the development of the E-Worksheet should align learning objectives, STEM activities, and assessment with the intended learning outcomes and the characteristics of elementary school students. The relationship among natural phenomena, technology, society, and the environment should also be maintained so that learning activities are not limited to product construction. Therefore, a STEM-based E-Worksheet can be positioned as an alternative digital teaching material that is appropriate for further development and evaluation.

4. CONCLUSION

Based on the assessment of two validators using a 1–5 scale, the STEM-based IPAS E-Worksheet obtained Aiken's V indices of 0.875 for the material aspect, 0.750 for the language aspect, 0.875 for the display aspect, and 0.875 for STEM integration, with an overall average score of 0.844, which was categorized as very valid. These results indicate that, in general, the E-Worksheet has met the feasibility criteria in terms of alignment with IPAS learning outcomes, clarity and readability of language, quality of design and navigation, and integration of science, technology, engineering, and mathematics in the learning activities. Nevertheless, the language aspect obtained the lowest score and therefore requires further attention, particularly regarding the clarity of instructions, simplicity of sentence structure, and consistency of terminology to better suit the characteristics of elementary school students. Overall, the STEM-based IPAS E-Worksheet is appropriate to proceed to the next stage of development after revisions based on validator feedback, followed by practicality and effectiveness testing so that the quality of the product can be evaluated more comprehensively.

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