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Validity Analysis of Socio-Scientific Issues (SSI)-Based Student Worksheets on Climate Change Using Aiken's V

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Abstract: This study aimed to analyze the validity of a Socio-Scientific Issues (SSI)-based student worksheet on climate change using Aiken's V index. The study was conducted as part of research and development employing the 4D model, with a specific focus on the *develop* stage, particularly expert validation and product revision. Three validators assessed 20 items covering five aspects: content feasibility, SSI characteristics, construction and presentation, language, and graphic design. Data were collected using a validation form with a five-point rating scale and quantitatively analyzed using Aiken's V index. The validators' comments and suggestions were analyzed descriptively and used as the basis for product revision. The results showed that the Aiken's V values for individual items ranged from 0.667 to 0.917. Nine items were categorized as highly valid, while eleven items were categorized as valid. The overall mean validity score was 0.779, indicating that the worksheet was valid. The construction and presentation aspect obtained the highest validity score of 0.813, whereas the language aspect received the lowest score of 0.750. The components requiring further improvement were primarily related to the depth of the learning content, the adequacy of scientific data and evidence, consistency in the use of scientific terminology, and coherence of the learning activity sequence. Therefore, the SSI-based student worksheet on climate change was considered valid and suitable for classroom trials after minor revisions were made in accordance with the validators' recommendations.

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Introduction

Climate change is a multidimensional issue shaped by interactions among atmospheric systems, ecosystems, human activities, socioeconomic conditions, technological developments, and public policies. Therefore, climate change education should not be limited to the mastery of definitions and concepts; it should also help students interpret scientific evidence, understand causal relationships, evaluate alternative courses of action, and make accountable decisions. This orientation is consistent with the need to develop climate literacy, critical thinking skills, environmental awareness, and students' readiness to participate in climate change mitigation and adaptation efforts (IPCC, 2023; Kolenatý et al., 2022; Monroe et al., 2019; UNESCO, 2024).

The Socio-Scientific Issues (SSI) approach provides a relevant instructional framework because it connects scientific concepts with complex and controversial social problems that may involve multiple perspectives and alternative decisions. In SSI-based learning, students are encouraged to evaluate the credibility of information, analyze evidence, compare different perspectives, construct arguments, and consider social, economic, ethical, and environmental

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dimensions (Karisan & Zeidler, 2017; Li & Guo, 2021; Sadler et al., 2016; Yacoubian & Khishfe, 2018). Climate change is particularly appropriate as an SSI context because it is closely related to energy use, waste management, deforestation, industrial emissions, consumption patterns, and emission-reduction policies.

To ensure that SSI-based learning extends beyond merely presenting an issue, instructional materials are needed to guide students through problem orientation, information analysis, evidence evaluation, argument construction, decision-making, and reflection. A student worksheet can serve this function when it includes authentic issues, sufficient scientific data, analytical questions, opportunities to compare different perspectives, and evidence-based decision-making tasks. Previous studies have shown that SSI-based student worksheets and electronic student worksheets have the potential to support students' scientific literacy and argumentation skills. However, the quality of these products depends on the accuracy and depth of the content, the organization of learning activities, the clarity of the language, the quality of the presentation, and the integration of SSI characteristics (Ameliawati et al., 2021; Chomsun et al., 2024; Fajarani et al., 2025; Qalfin et al., 2024).

Biology instructional materials and media have also been developed in various forms, including a research-based applied biology module on the use of anthocyanins as biosensors (Arifin et al., 2022), learning tools based on the Culturally Responsive Transformative Teaching model integrated with an SSI approach (Arifin et al., 2024a), an SSI-based ecosystem e-module (Arifin et al., 2024b), and Mini Virtual Aquatic Ecosystem learning media (Arifin, 2024c). Project-based learning training involving practical science tools has also demonstrated the importance of providing instructional resources and learning experiences that are relevant to the characteristics of biology content (Arifin et al., 2023). Furthermore, research on the content and construct validity of SSI-based learning tools has emphasized that expert judgment is an essential stage before a product is implemented in classroom instruction (Arifin et al., 2025).

Expert validation is required before an LKPD is used by students to evaluate content representativeness, construct appropriateness, language clarity, presentation quality, and graphic design. Aiken's V index can be used to quantify the degree of agreement among validators regarding the relevance of each item. Nevertheless, the index provides only evidence of content validity based on expert judgment. Therefore, the interpretation of Aiken's V values should be supported by raw ratings, validator profiles, confidence intervals where available, and qualitative comments as a basis for product revision. Expert-validation results alone cannot be used to draw conclusions regarding the practicality or effectiveness of an instructional product (Aiken, 1985; Mastaglia et al., 2003; Penfield & Giacobbi, 2004; Polit & Beck, 2006).

The LKPD analyzed in the present article is the same instructional product examined by Hasanah et al. (2026). However, the present study addresses different research questions, applies a different analytical focus, and uses a different dataset. The previous publication used student trial data to examine the practicality of the product and its effectiveness in improving students' scientific attitudes. In contrast, the present article exclusively analyzes expert-rating scores and validators' comments collected during the validation stage. No pretest–posttest data, N-gain results, practicality data, or effectiveness findings from the previous study were reused. This separation of research focus and datasets was intended to provide a detailed account of content-validity evidence while avoiding duplication of previously reported results.

The novelty of this study lies in its item- and aspect-level analysis of the content validity of an SSI-based climate change LKPD for Grade 10 students, accompanied by the identification of components requiring revision before classroom trials. Accordingly, this study aimed to analyze the degree of agreement among validators regarding content feasibility, SSI

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characteristics, construction and presentation, language, and graphic design. It also sought to integrate the quantitative results obtained through Aiken's V analysis with the validators' qualitative comments as a basis for revising the product.

Research Method

Research Design

This study was part of a research and development project employing the 4D model, which consists of the *define*, *design*, *develop*, and *disseminate* stages (Thiagarajan et al., 1974). The present article specifically reports the *develop* stage, particularly expert validation and product revision. The *define* and *design* stages are described only as the developmental context of the product. Data concerning practicality and effectiveness were not analyzed in this article because they were reported separately by Hasanah et al. (2026). Therefore, the units of analysis in the present study were the expert ratings and qualitative comments for each item and aspect of the Socio-Scientific Issues (SSI)-based student worksheet on climate change.

Development Context and Validated Product

The validated product was an SSI-based student worksheet designed for Grade 10 students studying climate change. The worksheet was developed based on curriculum analysis, student-characteristic analysis, concept analysis, and learning-needs analysis. It was designed to connect climate change concepts with authentic social and environmental issues through activities involving issue orientation, problem identification, analysis of scientific information and evidence, argument construction, decision-making, and reflection. The product was intended for implementation at MAS Al-Chalil as part of the broader development project. However, the present article exclusively analyzed data obtained during the expert-validation stage and did not include data collected from students during subsequent field trials.

Validators

Product validation involved three validators who were purposively selected based on their expertise relevant to the developed product, experience in educational research or instructional-material development, and ability to assess the content and construction of the worksheet. The validation panel consisted of a subject-matter expert, an instructional-material development expert, and a teacher or educational practitioner. Each validator received the worksheet draft, validation form, rating instructions, and an explanation of the objectives and constructs being assessed. The validators evaluated the product independently to minimize the possibility of mutual influence during the rating process.

Validation Instrument

Data were collected using an expert-validation form developed with reference to student worksheet characteristics, SSI-based learning principles, the scientific accuracy of climate change content, and instructional-material development standards. The instrument consisted of 20 statements covering five aspects: content feasibility, SSI characteristics, construction and presentation, language, and graphic design. Each statement was rated using a five-point scale, ranging from 1, representing the lowest level of appropriateness, to 5, representing the highest level of appropriateness. In addition to numerical ratings, the validation form provided space for validators to submit comments, corrections, and recommendations for product revision.

Validation and Product-Revision Procedures

The validation and revision procedures were conducted in four stages. First, the researchers prepared the worksheet draft and validation instrument based on the results of the *define* and *design* stages. Second, the validators independently assessed each statement using the predetermined rating scale and provided qualitative comments. Third, the validators' scores were tabulated and analyzed using Aiken's V index at the item and aspect levels. Fourth, the worksheet was revised based on the Aiken's V results and the validators' recommendations.

Items that did not meet the predetermined acceptance criteria were prioritized for revision. Items that met the criteria could also be revised when validators provided substantive comments concerning conceptual accuracy, language clarity, SSI characteristics, activity coherence, or graphic presentation. The revision process was documented in a matrix containing the evaluated component, validators' comments, the researchers' decisions, and the revisions made. This documentation provided evidence that the expert feedback had been addressed before the worksheet proceeded to the field-trial stage.

Quantitative Data Analysis

The expert-rating scores were analyzed using Aiken's V index to determine the degree of agreement among the validators regarding the relevance and appropriateness of each item. Aiken's V was calculated using the following equation (Aiken, 1985):

$$V = \Sigma s / [n(c - 1)]$$
$$\text{where } s = r - l_0$$

In the equation, r represents the score assigned by a validator, l_0 represents the lowest possible score on the rating scale, c represents the highest possible score, and n represents the number of validators. In this study, $l_0 = 1$, $c = 5$, and $n = 3$.

Aiken's V was calculated separately for each item. The mean Aiken's V value for each aspect was obtained by averaging the item-level values within that aspect, whereas the overall mean validity value was calculated by averaging the values of all 20 items. Aiken's V values range from 0 to 1, with values closer to 1 indicating a higher level of agreement among validators.

The operational criteria presented in Table 1 were used to support product-revision decisions. These criteria served as descriptive guidelines for interpreting the validation results rather than as universal statistical cutoff values.

Table 1. Operational Criteria for Interpreting Aiken's V Index

Aiken's V Range	Interpretation	Decision
$V \geq 0.80$	Highly valid	Retained; minor revisions were made when substantive recommendations were provided.
$0.40 \leq V < 0.80$	Valid	Reviewed and revised based on the item score and validators' comments.
$V < 0.40$	Less valid	Substantially revised and reassessed when necessary.

Qualitative Data Analysis

The validators' comments and recommendations were analyzed descriptively. The analysis involved grouping the comments according to the five validation aspects, identifying

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the problems raised by the validators, determining revision priorities, and documenting the actions taken in response to each recommendation.

The qualitative data were used to explain the quantitative Aiken's V results and provide a substantive basis for revising the product. The findings were documented in a revision matrix presenting the product condition before revision, the validators' comments, the researchers' decisions, and the modifications made to the worksheet. This integration of quantitative ratings and qualitative feedback provided a more comprehensive basis for evaluating and improving the SSI-based student worksheet.

Result and Discussion

This section presents the validity results of the Socio-Scientific Issues (SSI)-based student worksheet on climate change based on assessments conducted by three validators. The analysis covered 20 items distributed across five aspects: content feasibility, SSI characteristics, construction and presentation, language, and graphic design. The quantitative results were analyzed using Aiken's V at the item, aspect, and overall levels. The validators' qualitative comments were also considered to identify components requiring revision before the worksheet proceeded to the field-testing stage.

Validity Results by Aspect

Table 2. Summary of Aiken's V Values by Validation Aspect

No.	Validation Aspect	Number of Items	Mean V	Category
1	Content feasibility	5	0.783	Valid
2	SSI characteristics	5	0.767	Valid
3	Construction and presentation	4	0.813	Highly valid
4	Language	3	0.750	Valid
5	Graphic design	3	0.778	Valid
	Overall	**20**	**0.779**	**Valid**

As shown in Table 2, the overall mean Aiken's V value was 0.779, indicating that the SSI-based student worksheet met the validity criteria but still required several revisions before proceeding to field testing. Of the 20 items analyzed, nine were categorized as highly valid and eleven as valid. No item was categorized as less valid. The construction and presentation aspect obtained the highest mean value of 0.813, whereas the language aspect obtained the lowest mean value of 0.750. These results indicate that the organization of activities, instructions, and task presentation was evaluated positively, while greater attention was required to improve the consistency of scientific terminology and the clarity of several sentences.

The content feasibility aspect obtained a mean Aiken's V value of 0.783. This result indicates that the content was generally aligned with the learning outcomes and relevant climate change concepts. However, the depth of the material in several sections needed to be adjusted to the cognitive development of Grade 10 students. The SSI characteristics aspect obtained a mean value of 0.767, indicating that the worksheet successfully connected scientific concepts with social and environmental issues. Nevertheless, the presentation of scientific evidence and the inclusion of multiple perspectives required further improvement. The graphic design aspect obtained a mean value of 0.778, suggesting the need for minor revisions related to color contrast, layout consistency, and the clarity of visual data.

Item-Level Validity Results

Table 3. Item-Level Aiken's V Results

No.	Aspect	Item	V	Category
1	Content feasibility	Alignment of the content with the learning outcomes	0.833	Highly valid
2		Accuracy of climate change concepts	0.750	Valid
3		Currency of the data and facts presented	0.833	Highly valid
4		Appropriateness of content depth for students' developmental level	0.667	Valid
5		Relationship between concepts and local environmental phenomena	0.833	Highly valid
6	SSI characteristics	Authenticity and relevance of the issues presented	0.750	Valid
7		Connection between science and society	0.833	Highly valid
8		Inclusion of multiple perspectives	0.750	Valid
9		Adequacy of scientific data and evidence for analysis	0.667	Valid
10		Activities promoting decision-making and ethical consideration	0.833	Highly valid
11	Construction and presentation	Clarity of the worksheet instructions	0.833	Highly valid
12		Logical and systematic sequence of activities	0.750	Valid
13		Tasks and response spaces supporting student engagement	0.917	Highly valid
14		Integration of issues, analysis, argumentation, decision-making, and reflection	0.750	Valid
15	Language	Appropriateness of language for students' developmental level	0.750	Valid
16		Use of effective and unambiguous sentences	0.833	Highly valid
17		Consistent use of scientific terminology	0.667	Valid
18	Graphic design	Layout supporting the sequence of learning activities	0.833	Highly valid
19		Illustrations, tables, and visual data supporting understanding	0.750	Valid
20		Readability of font size, colors, and contrast	0.750	Valid

The item-level analysis produced Aiken's V values ranging from 0.667 to 0.917. Nine items were categorized as highly valid, whereas eleven items were categorized as valid. No item obtained a value below 0.40. The overall mean value of 0.779 indicates that the worksheet met the validity criteria and could proceed to the next development stage after the recommended revisions had been completed.

Content Feasibility

The content feasibility aspect obtained Aiken's V values ranging from 0.667 to 0.833, with a mean value of 0.783. Alignment with the learning outcomes, currency of the data and

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facts, and the relationship between climate change concepts and local environmental phenomena each obtained a value of 0.833. These results indicate that the worksheet content was relevant to the intended learning outcomes and connected climate change concepts with environmental problems encountered in students' daily lives.

The accuracy of climate change concepts obtained a value of 0.750, whereas the appropriateness of content depth obtained a value of 0.667. Although both items met the validity criteria, revisions were still required to improve the accuracy of scientific explanations and adjust the depth of the material to the cognitive development of Grade 10 students.

SSI Characteristics

The SSI characteristics aspect obtained Aiken's V values ranging from 0.667 to 0.833, with a mean value of 0.767. The connection between science and society and the activities promoting decision-making and ethical consideration each obtained the highest value of 0.833. These findings indicate that the worksheet incorporated essential SSI characteristics by relating scientific concepts to social and environmental problems.

The authenticity of the issues and the inclusion of multiple perspectives each obtained a value of 0.750. The adequacy of scientific data and evidence obtained the lowest value within this aspect, namely 0.667. Therefore, the worksheet needed to be supplemented with more recent data, clearly identified information sources, and sufficient scientific evidence to enable students to compare alternatives and formulate evidence-based decisions.

Construction and Presentation

The construction and presentation aspect obtained Aiken's V values ranging from 0.750 to 0.917, with a mean value of 0.813, placing it in the highly valid category. The item concerning tasks and response spaces supporting student engagement obtained the highest value among all items, namely 0.917. The clarity of the worksheet instructions obtained a value of 0.833, indicating that the instructions were generally clear and understandable.

The logical sequence of activities and the integration of issues, analysis, argumentation, decision-making, and reflection each obtained a value of 0.750. Although these components were valid, the transitions between stages needed to be clarified to ensure that students could move systematically from issue orientation to evidence analysis, argument construction, decision-making, and reflection.

Language

The language aspect obtained Aiken's V values ranging from 0.667 to 0.833, with a mean value of 0.750. The use of effective and unambiguous sentences obtained a value of 0.833, whereas the appropriateness of language for students' developmental level obtained a value of 0.750. The consistent use of scientific terminology obtained the lowest value within this aspect, namely 0.667. Revisions were therefore required to standardize terminology related to climate change, greenhouse gases, mitigation, adaptation, carbon emissions, and global warming. Brief explanations should also be provided for scientific terms that may be unfamiliar to students.

Graphic Design

The graphic design aspect obtained Aiken's V values ranging from 0.750 to 0.833, with a mean value of 0.778. The layout supporting the sequence of learning activities obtained a value of 0.833. Meanwhile, the use of illustrations, tables, and visual data, as well as the readability of font sizes, colors, and contrast, each obtained a value of 0.750.

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These results indicate that the visual presentation of the worksheet was generally appropriate. However, several improvements were required, including the use of more informative illustrations, simplified tables, clearer labels for graphs and infographics, and more consistent font sizes and color contrast.

Overall, construction and presentation was the strongest validation aspect, with a mean value of 0.813, whereas language obtained the lowest mean value of 0.750. The highest item-level value was obtained for tasks and response spaces supporting student engagement, with a value of 0.917. The lowest value of 0.667 was obtained for content depth, adequacy of scientific data and evidence, and consistency of scientific terminology. These findings indicate that the worksheet met the validity criteria but required revisions related primarily to content depth, scientific evidence, terminology, and the coherence of the learning activity sequence.

Validators' Comments and Follow-Up Revisions

In addition to the numerical ratings, the validators' comments were analyzed to identify specific improvements required for the worksheet. The comments were grouped according to the validation aspects and used as the basis for product revision.

Table 4. Validators' Comments and Follow-Up Revisions

No.	Component	Validator's Comment	Follow-Up Revision
1	Content	The temperature and emissions data should include the year and clearly identified sources.	The year and source of the data were added to each relevant table and infographic.
2	SSI characteristics	The climate change cases should be more closely related to students' local contexts.	Cases involving seasonal changes, droughts, and floods relevant to the local area were incorporated.
3	Evidence analysis	The supporting information was insufficient for comparing alternative solutions.	Additional data sources presenting different perspectives and evidence-evaluation questions were included.
4	Language	Several instructional sentences were too long, and some scientific terms were used inconsistently.	Complex instructions were divided into shorter sentences, and key scientific terms were standardized.
5	Graphic design	The color contrast in several tables and response spaces was insufficient.	The contrast was improved, font sizes were adjusted, and the response spaces were reorganized.

The revisions addressed both the quantitative results and the qualitative feedback provided by the validators. Consequently, the revised worksheet contained more clearly sourced scientific data, locally relevant climate change issues, stronger evidence-analysis activities, more consistent terminology, and improved visual readability.

Conclusion

The SSI-based student worksheet on climate change obtained an overall mean Aiken's V value of 0.779 and was categorized as valid. Construction and presentation obtained the highest mean

value of 0.813, whereas language obtained the lowest mean value of 0.750. These results indicate that the worksheet met the validity criteria and could proceed to field testing after revisions had been completed. The primary revisions involved improving the consistency of scientific terminology, simplifying several instructions, strengthening the scientific evidence and diversity of SSI perspectives, adjusting the depth of the material, and improving visual readability.

Recommendation

The SSI-based student worksheet on climate change should be revised before wider implementation, particularly by improving the depth and accuracy of the content, strengthening the adequacy and currency of scientific evidence, ensuring the consistent use of scientific terminology, clarifying the sequence of learning activities, and enhancing visual readability. Future studies should involve a larger and more diverse panel of validators to obtain broader expert perspectives and may include confidence intervals or additional measures of inter-rater agreement to strengthen the interpretation of content-validity evidence.

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