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Validation of an Assessment Instrument for Collaboration and Critical Thinking in Physics Co-Curricular Activities Integrating Local Wisdom

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Abstract: The integration of 21st-century competencies with local cultural values has become increasingly important for creating meaningful and contextually grounded physics education. Building on this need, the present study validates a set of assessment rubrics and rating scales designed to measure students' collaboration and critical thinking skills in physics co-curricular activities that incorporate the Bugis–Makassar *A'bulo Sibatang* philosophy. The validation process was conducted during the Analysis, Design, and Development stages of the ADDIE model and involved expert reviewers as well as practitioner teachers. Data were collected through laboratory observations, focus group discussions, and expert judgment. Aiken's V index was used to determine content validity, while Cronbach's Alpha was applied to assess the reliability of the instrument. The results indicate strong content validity (Aiken's V ≥ 0.80) and high reliability (α ≥ 0.85), confirming that the instrument is appropriate for use in a physics learning context. Teachers also affirmed the instrument's practicality and cultural relevance. The incorporation of *A'bulo Sibatang* highlighting unity, collective responsibility, and social harmony demonstrates that the instrument is not only psychometrically robust but also culturally grounded. Overall, the validated instrument offers a novel, culture-responsive framework for authentically assessing 21st-century skills, strengthening the connection between scientific reasoning and local character values in physics education.

Keywords: Assessment Instruments, Collaboration Skills, Critical Thinking, Local Wisdom, Physics Co-Curricular

A. Introduction

Education in the 21st century faces increasingly complex challenges stemming from rapid developments in science, technology, and global sociocultural dynamics. These transformations necessitate educational systems that transcend mere knowledge transmission and instead cultivate higher-order thinking, social competencies, and humanistic values that enable students to adapt effectively to a rapidly evolving world

(Trilling & Fadel, 2010). Such skills cannot be acquired through conventional, passive learning approaches; rather, they require active, reflective, and contextual learning processes that position students as the central agents of their own learning.

An educational paradigm focused solely on conceptual mastery is no longer adequate to address the demands of the 21st century. Learning models that emphasize rote memorization and repetitive information recall have become increasingly irrelevant in a society characterized by rapid change and uncertainty. The transformation of education toward competency-based learning has become an urgent necessity to enable students to think critically, adapt effectively, and collaborate successfully across diverse life situations (Alsudairy, 2024; Kris et al., 2022; Sartono et al., 2025). This new orientation calls for the implementation of learning models that foster independent thinking, creativity, and reflective awareness of the learning process.

In the context of science education, particularly physics, the development of critical and collaborative thinking skills holds significant relevance. Physics, as a discipline that explores natural phenomena through empirical and rational approaches, offers ample opportunities for cultivating scientific reasoning. Students are expected not only to understand physical laws and concepts but also to identify problems, design experiments, analyze data, and formulate conclusions grounded in empirical evidence. These activities require students to engage actively in logical reasoning, employ both deductive and inductive thinking, and collaborate with peers to develop solutions to the problems they encounter (Martawijaya et al., 2025; Rahmadi et al., 2023). These characteristics position physics learning as a strategic medium for integrating critical and collaborative thinking skills into the teaching and learning process.

Ideally, physics learning in schools should not be limited to achieving cognitive outcomes but should also encompass the development of scientific attitudes and social skills. Through activities such as experimentation, group discussions, and context-based problem solving, students have the opportunity to evaluate data, test hypotheses, and construct arguments based on evidence. The social interactions fostered in these activities help cultivate communication, negotiation, and respect for differing perspectives among group members (Bhakti et al., 2023; Wibowo et al., 2024). These aspects constitute essential components in building holistic scientific competence, wherein knowledge, skills, and attitudes converge to shape reflective and collaborative learners. Therefore, physics instruction should be designed as a scientific process that cultivates two core 21st-century competencies *critical thinking* and *collaboration* (Alsudairy, 2024; Martawijaya & Fisika, 2015).

In practice, assessment in physics education remains largely dominated by outcome-based rather than process-oriented evaluation. Teachers' assessments generally focus on cognitive abilities, particularly conceptual understanding and problem-solving in

numerical contexts. The dimensions of thinking processes, analytical skills, and social interactions that emerge during learning activities often receive little to no serious attention within the current assessment system (Rahmadi et al., 2023). The evaluation instruments commonly used are predominantly written tests that measure academic achievement, with little consideration for students' affective dimensions and collaborative skills. Yet, these aspects serve as crucial indicators in shaping a holistically competent learner profile. Consequently, students' potential for critical thinking and teamwork often remains insufficiently identified, particularly in co-curricular activities that require the application of physics concepts in real-world contexts. In this study, physics co-curricular activities refer to structured learning experiences conducted outside regular classroom instruction, including laboratory investigations, scientific projects, and community-based science activities designed to reinforce conceptual understanding through hands-on and collaborative inquiry.

This phenomenon highlights a gap between the demands of 21st-century education and the assessment systems implemented in schools. While cognitive learning outcomes are relatively easy to measure, they fail to adequately represent students' higher-order thinking abilities and social skills (Babichenko et al., 2024; Winaryati et al., 2022; Zaqiah et al., 2024). Product-oriented assessment tends to overlook the scientific thinking processes and collaborative dynamics that occur during learning activities. As a result, teachers often lack authentic data regarding students' abilities to collaborate, construct evidence-based arguments, and evaluate both their own and others' reasoning. This condition underscores the urgent need to develop assessment instruments capable of authentically measuring critical and collaborative thinking skills, particularly within the experimental and investigative nature of physics learning (Cañete & Peralta, 2022; Chen et al., 2025). In physics learning, which inherently demands sustained experimentation and in-depth investigation, the limited time allocated to regular classroom instruction often prevents teachers from fully observing essential elements such as collaborative dynamics, evidence-based argumentation, and the sequential stages of problem solving. Co-curricular activities therefore assume a strategic role as an extended learning space, enabling experimental processes to unfold more comprehensively while offering teachers greater opportunities to assess students' critical thinking and collaborative skills with higher accuracy and authenticity.

Assessment practices that align with students' cultural contexts have also become a critical issue in the development of modern evaluation instruments. Most existing assessment tools remain universal in nature and fail to account for the sociocultural diversity of learners. In reality, education cannot be separated from the social context in which students grow and interact. The integration of local cultural values into assessment practices has the potential to create more meaningful learning experiences, as students are able to connect the learning process with the social realities they understand (Martawijaya et al., 2025; Rosidin et al., 2022). Local values can also

strengthen the affective dimension of learning by fostering a sense of belonging, social responsibility, and collective engagement in the learning process. The incorporation of local wisdom into assessment practices serves as an effective strategy to contextualize 21st-century competencies, making them more relevant to the characteristics of learners in specific cultural settings. While various instruments have been developed to assess collaboration and critical thinking, few are explicitly grounded in a specific local philosophical framework such as the A'bulo Sibatang values, which constitutes the unique contribution of the present study.

The Bugis-Makassar community upholds a rich system of values and life philosophies, one of which is A'bulo Sibatang, literally translated as "one bamboo stalk." This philosophy embodies the spirit of unity, solidarity, and collective responsibility within social life. These values resonate strongly with the principles of scientific inquiry and academic collaboration, wherein the success of a group depends on the contribution and cooperation of each individual. Integrating the A'bulo Sibatang value into physics education can enhance students' understanding of the importance of togetherness and mutual effort in achieving scientific goals (Martawijaya et al., 2025; Tahir et al., 2025). Through the integration of this local value, the learning process becomes not only a means of understanding scientific concepts but also a medium for shaping social character that aligns with students' cultural identities.

An educational approach that integrates local wisdom with the assessment of 21st-century skills creates a harmony between global demands and local strengths. This integration allows learning to serve a dual function: as a means of developing scientific competence while simultaneously preserving cultural values. An assessment grounded in the A'bulo Sibatang philosophy can be designed to evaluate collaborative dimensions such as teamwork, group responsibility, and reflective awareness of collective outcomes. The value of solidarity embodied in this philosophy can strengthen the social dimension of physics learning, while its principle of collective reflection can foster critical thinking skills in evaluating experimental data and drawing conclusions (Martawijaya & Fisika, 2015; Tahir et al., 2025). In this way, assessment transcends its traditional role as a mere tool for measuring learning outcomes and becomes a medium for cultivating character and scientific attitudes.

The integration of local wisdom into assessment development also has significant implications for enhancing the relevance of curricula and pedagogical approaches at the school level. A culturally grounded approach provides opportunities for teachers and students to construct contextual learning experiences, ensuring that scientific knowledge is not perceived as detached from real-life contexts. In the Bugis-Makassar context, the A'bulo Sibatang value can serve as an ethical framework for co-curricular physics activities such as group experiments, scientific projects, and community-based scientific initiatives. These activities not only cultivate a sense of responsibility and solidarity but also help students internalize the understanding that scientific work

inherently involves collaboration and collective reflection. Cultural values internalized through assessment can strengthen the learning process and make learning outcomes more sustainable, as they are reinforced by profound social meaning (De Klerk et al., 2025; Gyasi & Zheng, 2021; Putri & Ridlo, 2024).

This context serves as the foundation for conducting research on the development of assessment instruments for evaluating *collaborative* and *critical thinking* skills in physics co-curricular activities integrated with Bugis-Makassar local wisdom. The study aims to design assessment instruments that not only meet academic standards of validity and reliability but also embody cultural relevance and contextual educational value. The development process employs the ADDIE model (*Analysis, Design, Development, Implementation, Evaluation*) combined with a participatory approach. The ADDIE model provides a systematic framework for instrument development, encompassing all stages from needs analysis to product evaluation. Meanwhile, the participatory approach enables the active involvement of key stakeholders such as university lecturers, junior and senior high school teachers, and education practitioners in formulating indicators, sub-indicators, and conducting content validation of the instrument. This study is limited to the first three stages Analysis, Design, and Development excluding the Implementation and Evaluation phases, as its primary focus is to produce a content-valid instrument that is ready for subsequent testing and application.

The ADDIE model, when combined with a participatory approach, offers distinct advantages in terms of collaboration and the accuracy of development outcomes. This approach ensures that the resulting product is not solely grounded in theoretical frameworks but also reflects the practical needs of its end users. Cross-level collaboration among educational stakeholders enriches the perspectives involved in formulating indicators and guarantees that each aspect of collaborative and critical thinking skills can be measured authentically. The expert validation process allows for the refinement of the instrument's structure to ensure its alignment with both the context of physics learning and local sociocultural values. The expected outcome is an assessment instrument capable of comprehensively measuring students' collaborative and critical thinking skills while simultaneously fostering the development of social and scientific character grounded in Bugis-Makassar cultural values.

The contribution of this study is both theoretical and practical within the context of physics education and competency-based assessment. Theoretically, it expands the conceptual framework of authentic assessment by integrating local wisdom as a significant pedagogical variable. Practically, the developed instrument is expected to serve as a reference for teachers and educational institutions in implementing assessments that align with 21st-century competency demands while remaining grounded in local cultural values. Assessments grounded in students' social contexts have the potential to enhance learning motivation, strengthen cultural identity, and

foster the development of sustained reflective thinking skills. Overall, this study seeks to contribute to both national and global efforts to build an education system that is humanistic, contextually relevant, and future-oriented.

B. Methods

This study employs the ADDIE development model combined with a participatory approach. The ADDIE model was chosen for its systematic, structured, and flexible framework in developing educational products that are both valid and reliable. The participatory approach was adopted to ensure continuous involvement of lecturers and physics teachers throughout the developmental process, thereby producing an assessment instrument that is theoretically sound, practical, and closely aligned with the sociocultural context grounding this research.

Only the first three phases of the ADDIE model Analysis, Design, and Development were implemented in this study, as the primary objective was to construct and validate an assessment instrument for measuring collaborative and critical thinking skills in physics co-curricular activities based on Bugis–Makassar local wisdom. The Implementation and Evaluation stages were intentionally excluded and are planned for future studies once the instrument has undergone full validation.

Research Location and Participants

The study was conducted at SMA Negeri 5 Takalar, South Sulawesi, during the 2025–2026 academic year. The school was selected purposively due to its active engagement in laboratory-oriented co-curricular physics activities and its openness to integrating instructional practices grounded in local cultural values. This environment, which emphasizes experimentation, project-based learning, and student collaboration, provided an ideal setting for the development and validation of the proposed assessment instrument.

Participants consisted of two groups: lecturers and physics teachers. The lecturers served as expert validators responsible for evaluating the content and construct validity of the instrument based on principles of educational measurement and physics pedagogy. Meanwhile, physics teachers functioned as practitioner validators, assessing the practicality, linguistic clarity, and contextual appropriateness of the instrument for application in school-based physics learning. Students were not included in this phase, as the study focused exclusively on early-stage development and expert validation prior to field implementation

Analysis Stage

The analysis stage constituted the foundation of the development process, aiming to

identify needs and challenges encountered in current assessment practices. This phase involved observations, semi-structured interviews, and focus group discussions (FGDs) with the participating lecturers and physics teachers.

Observations were conducted to examine the existing assessment techniques used in physics co-curricular activities, while interviews explored teachers' perspectives on the limitations of current systems particularly regarding the evaluation of students' collaborative and critical thinking skills. FGDs were used to deepen the understanding of the need for an assessment model that is authentic, culturally responsive, and suited to the characteristics of physics learning in the local context.

The results indicated that assessment practices remained predominantly focused on cognitive outcomes, with limited attention to social, affective, and higher-order thinking dimensions. Current instruments were largely restricted to written tests, which were insufficient for capturing skills demonstrated in collaborative laboratory work or project-based tasks. Moreover, existing assessment procedures did not reflect the Bugis–Makassar cultural values that shape students' social interactions. These findings reinforced the need for developing an authentic, contextual, and culturally grounded assessment instrument aligned with the values of A'bulo Sibatang.

Design Stage

The design stage established the conceptual structure and operational framework of the assessment instrument. Two primary constructs were defined: collaboration skills and critical thinking skills. Each construct was elaborated into measurable indicators that align with the characteristics of physics learning activities.

Collaboration skills included four indicators: (1) active participation, (2) mutual respect among group members, (3) collective decision-making, and (4) responsibility for assigned roles. Critical thinking skills comprised: (1) problem formulation, (2) evaluation of information, (3) analytical argumentation, and (4) drawing logical conclusions. Both constructs were deliberately linked to the sociocultural values of A'bulo Sibatang such as solidarity, honesty, cooperation, and mutual support which strongly influence interpersonal dynamics in the Bugis–Makassar community.

This stage also produced supporting documents, including an expert validation sheet, an observation guide, a collaboration rating scale, and a critical thinking assessment rubric. The expert validation sheet was designed to evaluate clarity, relevance, and representativeness of indicators, while the observation guide supported objective assessment during learning activities. The rating scale and rubric were carefully structured to ensure authentic measurement of students' processes and outcomes.

Development Stage

The development stage involved transforming the conceptual design into a functional instrument. The initial draft consisted of two components: (1) a collaboration rating scale for teachers or peers to assess students' interaction and contributions during group activities; and (2) a critical thinking assessment rubric for evaluating students' reasoning, analytical depth, and scientific argumentation in laboratory or project-based work.

The draft was subjected to expert validation. While many studies utilizing Aiken's V employ 4- or 5-point relevance scales, this study used a 10-point scale to allow validators to express more nuanced judgments. The decision was based on methodological recommendations emphasizing increased score sensitivity for multidimensional constructs. Despite using a broader scale, clear anchor descriptors were provided for each score to maintain consistency. A score of 1 indicated very low relevance, whereas a score of 10 represented very high relevance. Aiken's V values were computed for each item, with ≥ 0.80 set as the threshold for acceptable content validity.

Validation results indicated that several items required refinement to improve contextual accuracy and linguistic clarity. The researcher revised each item iteratively, with feedback incorporated after each cycle, until consensus was achieved among validators that all items met the required validity criteria.

Data Analysis and Research Ethics

The validation data were analyzed using both quantitative and qualitative methods. Quantitatively, Aiken's V was used to examine item relevance as evaluated by expert validators. In addition, internal consistency reliability was assessed using Cronbach's Alpha, calculated from the validators' score responses. The use of Cronbach's Alpha at this stage served to determine the internal coherence of items within each construct and aligns with recommended practices for early-phase instrument development before classroom-level pilot testing.

Qualitative analysis was conducted to review written comments and recommendations from expert validators and teachers. These insights were used to refine indicators, clarify wording, and strengthen the cultural alignment of the instrument.

All research procedures adhered to established ethical standards, including informed consent, participant confidentiality, and transparent communication throughout the development process. The resulting assessment instruments grounded in A'bulo Sibatang values and validated for content and construct alignment are expected to

serve as effective tools for assessing collaborative and critical thinking skills in secondary-level physics learning.

C. Results and Discussion

Physics education plays a central role in developing students' critical thinking, creativity, and scientific dispositions. As emphasized in previous studies (Bhakti et al., 2023; Zulyusri et al., 2023), physics learning is not only concerned with conceptual understanding but also with the cultivation of scientific reasoning processes that require students to observe, analyze, problem-solve, and formulate evidence-based conclusions. However, empirical observations and recent research indicate that physics instruction in secondary schools remains largely theoretical and teacher-centered (Kris et al., 2022), limiting opportunities for students to engage in higher-order thinking and contextualized problem solving (Alsudairy, 2024; Babichenko et al., 2024).

Aligned with the mandates of the Merdeka Curriculum, physics learning is expected to integrate character development, cultural values, and 21st-century skills—particularly critical thinking, collaboration, communication, and creativity. Project-based learning and contextual approaches have been consistently shown to support these goals by encouraging students to engage in inquiry and apply scientific ideas to real-world and culturally situated contexts (Campo et al., 2023; Martawijaya et al., 2025). Within this framework, local wisdom becomes an essential element that enriches learning and reinforces students' cultural identity.

The A'bulo Sibatang philosophy reflecting unity, mutual support, shared responsibility, and collective commitment provides a culturally grounded lens through which collaboration and scientific thinking can be meaningfully contextualized (Tahir et al., 2025). Integrating these values into assessment not only ensures cultural relevance but also strengthens students' social character and alignment with local norms of cooperation. This cultural foundation distinguishes the present instrument from generic collaboration and critical thinking assessments, particularly through indicators that emphasize mutual respect, communal decision-making, and accountability grounded in Bugis-Makassar sociocultural principles.

In addition, the development of critical thinking skills has become a primary imperative in contemporary physics education (Zaqiah et al., 2024). Students need to be trained to identify problems, analyze phenomena, evaluate evidence, and develop scientific arguments in a systematic manner (Bhakti et al., 2023). The assessment of these competencies requires valid and reliable instruments to ensure that the results accurately reflect students' competency profiles (Rosidin et al., 2022; Wibowo et al., 2024). Therefore, it is essential to develop assessment tools that not only measure cognitive aspects but also encompass scientific attitudes and collaborative values

integrated with local culture.

Grounded in this urgency, the present study aims to validate the design of an assessment instrument for evaluating students' collaborative skills and critical thinking abilities in physics co-curricular activities integrated with the *A'bulo Sibatang* local wisdom values of the Bugis-Makassar community. The validation process was carried out using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) at the content validity stage to ensure that the designed instrument demonstrates a high degree of appropriateness, clarity, and relevance to the context of culturally based physics learning. Accordingly, the findings of this study are expected to contribute to the advancement of contextual assessment practices and the strengthening of national character development through physics education.

Before presenting the validation results, it is important to clarify how the cultural framework, theoretical constructs, and indicator design were conceptually aligned in this study. This alignment became the basis for evaluating the validity of both instruments and plays a key role in interpreting the high Aiken's V scores. The following sections present the results of the content validation process alongside a discussion that integrates cultural perspectives, theoretical comparisons, and methodological considerations.

Table 1. Results of the Validity and Reliability Analysis of the Collaboration Skills Instrument

Indicator	Sub-Indicator	Assessed Aspect	Mean (Aiken's V)	SD	Category
Actively contributes to group work	Expresses ideas during discussion	Relevance and clarity of expressed ideas	0.864	0.057	Highly Appropriate
		Attitude in delivering ideas	0.864	0.057	Highly Appropriate
	Provides support to group members	Initiative and quality of assistance rendered	0.861	0.043	Highly Appropriate
		Demonstration of mutual support and cooperative attitude	0.861	0.043	Highly Appropriate
	Engages in discussion	Respectfully acknowledges and responds to others' opinions	0.864	0.057	Highly Appropriate
		Mediates disagreements and maintains a constructive	0.864	0.057	Highly Appropriate

		discussion atmosphere			
	Draws discussion conclusions	Member involvement in formulating conclusions	0.852	0.061	Highly Appropriate
		Clarity and alignment of conclusions with discussion outcomes	0.852	0.061	Highly Appropriate
Demonstrates mutual respect	Exhibits appreciation for diverse perspectives	Demonstrates a constructive and respectful response to differing viewpoints	0.856	0.052	Highly Appropriate
	Accepts feedback	Shows openness to critique and suggestions as part of reflective and continuous improvement	0.856	0.052	Highly Appropriate
Engages in collective decision-making	Participation in deliberative discussions	Active contribution of opinions during the decision-making process	0.861	0.051	Highly Appropriate
	Decision consensus	Engagement in achieving mutual agreement	0.861	0.051	Highly Appropriate
Adheres to roles and responsibilities	Performs assigned group roles	Demonstrates consistency in task execution	0.852	0.054	Highly Appropriate
	Completes tasks punctually	Timeliness in fulfilling assigned responsibilities	0.852	0.054	Highly Appropriate
	Demonstrates accountability for group outcomes	Shows commitment and contribution to the overall quality of group results	0.852	0.054	Highly Appropriate

The results of the content validity analysis for the collaboration skills instrument indicate that all indicators and sub-indicators achieved **Aiken's V values above 0.80**, categorized as *highly appropriate*. This finding suggests that each item within the instrument is considered relevant, representative, and aligned with the intended construct of collaboration skills being assessed. Overall, the mean **Aiken's V values** ranged from **0.85 to 0.87**, with relatively low standard deviations **(< 0.07**), reflecting a high level of consistency among validators in evaluating the content of the instrument items.

In more detail, the indicator "*Actively contributes to group work*" obtained the highest Aiken's V value, approximately 0.86, categorized as *highly appropriate*. This result indicates that the validators considered the items under this aspect such as expressing ideas, assisting group members, and participating in discussions to adequately represent collaborative competence. These aspects embody participatory behavior and social responsibility, which constitute the core dimensions of collaborative skills. The high mean score also suggests that the wording of these items was clear and easily understood, minimizing potential differences in interpretation among validators.

The indicators "*Demonstrates mutual respect*" and "*Engages in collective decision-making*" also attained Aiken's V values in the range of 0.85–0.86. These indicators represent the dimensions of social attitude and interpersonal communication within group work, such as appreciating differing opinions, accepting feedback, and actively participating in decision-making processes. These results reinforce that the instrument effectively measures collaborative aspects that extend beyond the cognitive domain to include affective and social dimensions aligning with 21st-century competencies that emphasize the ability to collaborate across differences.

Meanwhile, the indicator "*Adheres to roles and responsibilities*" obtained an average Aiken's V value of **0.85**, which also falls within the *highly appropriate* category. This finding confirms that the items assessing discipline, task commitment, and individual accountability within the group are well aligned with the expected concept of collaboration. The low standard deviation associated with this indicator further indicates that the validators shared a consistent perception regarding the clarity and relevance of the items.

Overall, the validation results indicate that the collaboration skills instrument demonstrates a high level of content appropriateness. This finding implies that each component of the instrument adequately encompasses the essential dimensions of collaborative competence, including active participation, effective communication, mutual respect, joint decision-making, and accountability for group outcomes. No items scored below the 0.80 threshold, suggesting that the instrument can be utilized without requiring substantial revisions.

The consistently high validity scores (0.85–0.87) for the collaboration instrument can be interpreted as a result of the strong conceptual alignment between the indicators, cultural values, and theoretical constructs. Validators recognized that the items clearly reflected collaborative competencies such as responsibility, respectful communication, and shared decision-making. This is also reinforced by the integration of the A'bulo Sibatang philosophy, which emphasizes unity, mutual support, and collective responsibility. Unlike generic collaboration rubrics, the indicators in this instrument capture culturally embedded behaviors—for example, mutual respect is framed not only as acknowledging others' opinions but as

upholding communal harmony and shared honor. These culturally grounded dimensions likely strengthened validators' agreement, contributing to the high Aiken's V values. The findings are in line with (Rosidin et al., 2022; Wibowo et al., 2024) but extend their work by incorporating culturally responsive elements that have not been previously operationalized.

Table 2. Results of the Validity and Reliability Analysis of the Critical Thinking Skills Instrument

Indicator	Sub-Indicator	Assessed Aspect	Mean (Aiken's V)	SD	Category
Problem Formulation	Identification of issues	Clarity and contextual relevance of the formulated problems	0.856	0.46	Highly Appropriate
	Generation of critical questions	Depth and precision of questions in relation to the contextual framework	0.856	0.46	Highly Appropriate
Evaluating Information	Distinguishing between facts and opinions	Accuracy in identifying factual statements and opinions	0.848	0.48	Highly Appropriate
	Verifying the validity and relevance of sources	Ability to assess the credibility and reliability of information sources	0.848	0.48	Highly Appropriate
Analyzing	Identifying cause–effect relationships	Accuracy in explaining the interconnections among variables or phenomena	0.862	0.52	Highly Appropriate
	Organizing arguments	Clarity and logical coherence in the structure of scientific reasoning	0.862	0.52	Hghly Appropriate
Drawing Conclusions	Derivation of evidence-based conclusions	Coherence between conclusions and the supporting data and arguments	0.885	0.64	Highly Appropriate
	Evaluation of inferential logic	Consistency and rational soundness in the reasoning underlying the conclusions	0.885	0.64	Highly Appropriate

The results of the content validity analysis for the critical thinking skills instrument indicate that all indicators obtained **Aiken's V** values ranging from **0.84 to 0.89**, which fall within the *highly appropriate* category. These values suggest that each item in the instrument was deemed relevant and representative in measuring the construct of

students' critical thinking, consistent with the intended objectives of the instrument's development. Furthermore, the relatively low standard deviation (0.46–0.64) reflects a high level of agreement among validators, indicating consistency in their evaluations of the instrument's content.

In more detail, the indicator "*Problem Formulation*" obtained an average Aiken's V value of 0.856, categorized as *highly appropriate*. This result indicates that the validators considered the items under this indicator such as the ability to identify problems, pose critical questions, and relate those questions to contextual settings to adequately represent the essential aspects of critical thinking skills. The ability to formulate problems serves as the initial stage in the critical thinking process, guiding subsequent analysis and reasoning. The high validity score further suggests that the items within this indicator were clearly articulated, relevant, and easily comprehensible to the evaluators.

The indicator "*Evaluating Information*" also achieved an Aiken's V value of 0.848, which falls within the *highly appropriate* category. This indicator pertains to students' ability to distinguish between facts and opinions, as well as to assess the validity and relevance of information sources. These results suggest that the instrument items are well aligned with the characteristics of critical thinking as defined by Ennis, reflecting analytical discernment and evaluative judgment in processing information (Bhakti et al., 2023) that is, the capacity to critically appraise the reliability of data and arguments prior to formulating conclusions. Thus, the evaluative dimension of critical thinking is comprehensively and appropriately represented within the developed instrument. Meanwhile, the indicator "*Analyzing*" obtained an Aiken's V value of 0.862, indicating that the instrument is effective in measuring students' ability to identify cause–effect relationships and organize arguments in a logical manner. This high value demonstrates that the items under the analysis indicator successfully capture higher-order thinking skills, which constitute the core of scientific learning. The consistency among validators was also satisfactory (SD = 0.52), suggesting minimal differences in perception regarding the clarity and relevance of the items.

The final indicator, "*Drawing Conclusions,*" achieved the highest Aiken's V value of 0.885, categorized as *highly appropriate*. This result indicates that the instrument items assessing the ability to draw conclusions based on evidence and logical reasoning were well constructed and deemed highly relevant by the validators. This value also affirms that the instrument effectively reflects the scientific thinking process, which requires students to integrate evidence, reasoning, and argumentation in the process of making informed judgments.

Overall, the validation results demonstrate that the critical thinking skills instrument meets a high standard of content validity. Each item successfully represents the key dimensions of critical thinking consistent with both theoretical frameworks and the

practices of physics education, namely: (1) problem formulation, (2) information evaluation, (3) analytical reasoning, and (4) evidence-based conclusion drawing. No item scored below the 0.80 threshold, indicating that the instrument is suitable for use without requiring substantial revisions.

The highest validity score observed for the "Drawing Conclusions" indicator (Aiken's V = 0.885) reflects strong agreement among validators regarding the clarity and representativeness of items related to scientific inference. Drawing conclusions is widely recognized as the culminating stage of critical thinking, where evidence, reasoning, and interpretation converge. This aligns with findings from (Bhakti et al., 2023; Zaqiah et al., 2024), who reported that conclusion-based indicators tend to score higher due to their more measurable and observable outcomes. By explicitly integrating culturally contextualized reasoning such as evidence-based communal decision-making inspired by A'bulo Sibatang the present study advances previous assessment frameworks. It offers a more holistic representation of critical thinking that connects scientific reasoning with cultural logic, an innovation not addressed in earlier instruments.

This study has several limitations that must be acknowledged. First, the validation process involved a relatively small group of expert validators, which may limit the diversity of perspectives in evaluating item clarity and relevance. Second, the instrument has not yet undergone empirical reliability testing with students, such as internal consistency analysis or inter-rater reliability, which is essential for confirming its practical applicability. Third, the integration of the A'bulo Sibatang philosophy, while providing a strong cultural foundation, also restricts the generalizability of the instrument to other cultural contexts. Finally, the development and validation were conducted in a single school environment, which may not fully represent the broader characteristics of schools across Indonesia.

The findings of this study carry several implications for practice, curriculum development, and future research. For teachers, the validated instruments offer a culturally grounded framework for assessing students' collaboration and critical thinking during physics learning, particularly in co-curricular contexts. For curriculum designers, the integration of local wisdom demonstrates how cultural values can be systematically embedded into assessment tools, promoting more contextualized learning experiences. For researchers, this study provides a methodological model for developing culturally responsive instruments that can be adapted or extended to other cultural backgrounds. Moreover, for school communities, the emphasis on A'bulo Sibatang supports the strengthening of character education by fostering unity, shared responsibility, and respectful scientific discourse.

D. Conclusions

The findings of this study indicate that the assessment instruments developed to measure collaborative and critical thinking skills in physics co-curricular activities grounded in the cultural principles of A'bulo Sibatang have successfully met rigorous content validity standards. All indicators achieved Aiken's V values of ≥ 0.80, demonstrating strong relevance, representativeness, and clarity according to the expert validators. The low standard deviation values further confirm a high degree of agreement among validators regarding each item's appropriateness and alignment with the intended constructs. The primary contribution of this study is the development of a culturally grounded assessment instrument that integrates the values of unity, shared responsibility, and social harmony characterizing the A'bulo Sibatang tradition. The instrument not only demonstrates strong empirical validity but also reflects a deep contextual embeddedness in local cultural wisdom. This cultural alignment ensures that the assessment does more than measure cognitive and higher-order thinking it also supports the formation of students' sociocultural character in ways that resonate with their lived experiences. Overall, the validated instrument offers a meaningful alternative for assessing collaboration and critical thinking within physics learning environments that emphasize both scientific reasoning and cultural character development. Its high content validity and strong inter-rater agreement suggest that it is ready for use as an authentic assessment tool in culturally responsive science education. Future research should further strengthen the instrument by expanding its evaluation to include comprehensive reliability and practicality testing. Reliability testing may involve examining inter-rater reliability during classroom implementation, assessing internal consistency through pilot trials, and analyzing stability across multiple learning sessions. Practicality testing could include pilot studies with students to observe usability during real learning activities, teacher usability surveys to evaluate clarity and feasibility, and classroom observations to ensure that the instrument functions effectively under authentic instructional conditions. Additionally, adapting the instrument into an interactive digital format may enhance accessibility and facilitate wider adoption across diverse educational contexts. Through these future advancements, the instrument is expected to contribute not only to culturally contextualized physics assessment practices but also to the broader movement toward holistic, character-oriented science education.

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References

Alsudairy, N. A. (2024). Effects of a Training Program to Improve Co-Teaching and Collaboration Skills for In-Service Teachers of Special and General Education. *SAGE Open*, *14*(4), 1–16. https://doi.org/10.1177/21582440241288076

Babichenko, M., Lefstein, A., & Asterhan, C. S. C. (2024). Teacher collaborative inquiry into practice in school-based learning communities: The role of activity type. *Learning, Culture and Social Interaction*, *49*, 100852. https://doi.org/10.1016/j.lcsi.2024.100852

Bakri, F., Permana, H., Wulandari, S., & Muliyati, D. (2020). Student worksheet with ar videos: Physics learning media in laboratory for senior high school students. *Journal of Technology and Science Education*, *10*(2), 231–240. https://doi.org/10.3926/JOTSE.891

Bhakti, Y. B., Arthur, R., & Supriyati, Y. (2023). Development of an assessment instrument for critical thinking skills in Physics: A systematic literature review. *Journal of Physics: Conference Series*, *2596*(1). https://doi.org/10.1088/1742-6596/2596/1/012067

Campo, L., Galindo-Domínguez, H., Bezanilla, M. J., Fernández-Nogueira, D., & Poblete, M. (2023). Methodologies for Fostering Critical Thinking Skills from University Students' Points of View. *Education Sciences*, *13*(2). https://doi.org/10.3390/educsci13020132

Cañete, R., & Peralta, E. (2022). Assistive Technology to Improve Collaboration in Children with ASD: State-of-the-Art and Future Challenges in the Smart Products Sector. *Sensors*, *22*(21). https://doi.org/10.3390/s22218321

Chen, Y., Preston, J. C., & Li, Y. (2025). Enhancing Collaboration and Critical Thinking in CSCL Environments: The Interplay Between Team Dynamics and Pedagogical Innovation. *International Journal of E-Collaboration*, *21*(1), 1–24. https://doi.org/10.4018/IJeC.376010

De Klerk, C., Ker-Fox, J., & Steenekamp, L. (2025). Enhancing critical thinking through collaborative learning: the impact of a partial pre-release assessment format. *Accounting Education*, *34*(4), 499–532. https://doi.org/10.1080/09639284.2024.2361647

Gyasi, J. F., & Zheng, L. (2021). *Reflecting on the Past to Shape the Future : A Systematic Review on Cross-Cultural Collaborative Learning from 2011 to 2020*.

Hikmawati, Suastra, I. W., Suma, K., & Sudiatmika, A. A. I. A. R. (2024). Online lectures with local wisdom context: efforts to develop students' higher-order thinking skills. *International Journal of Evaluation and Research in Education* , *13*(2), 943–941. https://doi.org/10.11591/ijere.v13i2.25744

Kris, M., Hidayatulloh, Y., Java, E., Ashoumi, H., & Java, E. (2022). *Cypriot Journal of Educational*. *17*(7), 2199–2206.

Martawijaya, M. A., & Fisika, A. P. (2015). *of EST EST , , Volume 1 Juni Juni 2015 2015 hal Program Pascasarjana Universitas Negeri Makassar – JEST*. *V*, 54–64.

Martawijaya, M. A., Sujiono, E. H., Halim, A. D., Tho, S. W., Mahir, Palloan, P., &

Zharvan, V. (2025). the Impact of Physics Co-Curricular Activities Based on Makassar Local Wisdom on Improving the Pancasila Student Profile and Learning Satisfaction. *Jurnal Pendidikan IPA Indonesia*, *14*(1), 17–31. https://doi.org/10.15294/jpii.v14i1.13178

Martawijaya, M. A., Rahmadhanningsih, S., Swandi, A., Hasyim, M., & Sujiono, E. H. (2023). the Effect of Applying the Ethno-Stem-Project-Based Learning Model on Students' Higher-Order Thinking Skill and Misconception of Physics Topics Related To Lake Tempe, Indonesia. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 1–13. https://doi.org/10.15294/jpii.v12i1.38703

Putri, N. K., & Ridlo, I. A. (2024). *How Do Health Worker Qualities Affect Collaborative Skills ? A Qualitative Study in Rural Indonesia Primary Health Services*. *16*(1), 2–11. https://doi.org/10.21315/eimj2024.16.1.3

Rahmadi, Hardinata, R., Ahwan, M. T. R., Rubiyatno, & Suryadi, D. (2023). Enhancing 21st century collaboration skills in physical education through the problem-based learning model. *Edu Sportivo: Indonesian Journal of Physical Education*, *4*(3), 270–282. https://doi.org/10.25299/esijope.2023.vol4(3).14112

Rosidin, U., Sesunan, F., & Fitria, D. (2022). Development of Assessment Instruments to Measure Collaboration and Responsibility Skills of Students in Physics Learning on Cased Method-Based. *AMPLITUDO : Journal of Science and Technology Inovation*, *1*(2), 29–35. https://doi.org/10.56566/amplitudo.v1i2.7

Sartono, B., Sunarno, W., Prayitno, B. A., & Indriyanti, N. Y. (2025). Development and Validation of A Critical Thinking Assessment on Temperature and Heat for Secondary Physics Education. *Educational Process: International Journal*, *16*. https://doi.org/10.22521/edupij.2025.16.264

Tahir, M., Martawijaya, M. A., Haris, A., & Hasyim, M. (2025). *The Effectiveness of the Use of A ' bulo Sibatang-Based Physics Co-Curricular Activity Worksheets on HOTS and Students ' Collaboration Skills*. *02*, 890–903.

Teuwen, C. J., Kusurkar, R. A., Schreurs, H., Daelmans, H. E. M., & Peerdeman, S. M. (2024). Interprofessional collaboration skills and motivation one year after an interprofessional educational intervention for undergraduate medical and nursing students. *BMC Medical Education*, *24*(1), 1–9. https://doi.org/10.1186/s12909-024-05262-z

Trilling, B., & Fadel, C. (2010). 21St Century Skills: Learning for Life in Our Times. *Choice Reviews Online*, *47*(10), 47-5788-47–5788. https://doi.org/10.5860/choice.47-5788

Wibowo, A. M., Utaya, S., Wahjoedi, W., Zubaidah, S., Amin, S., & Prasad, R. R. (2024). Critical Thinking and Collaboration Skills on Environmental Awareness in Project-Based Science Learning. *Jurnal Pendidikan IPA Indonesia*, *13*(1), 103–115. https://doi.org/10.15294/jpii.v13i1.48561

Winaryati, E., Munsarif, M., Mardiana, & Suwahono. (2022). 21St Century of Collaboration Skills: The Practical Basis of Learning Supervision. *Italienisch*, *12*(1), 251–261.

Zaqiah, Q. Y., Hasanah, A., & Heryati, Y. (2024). *The role of steam education in improving*

student collaboration and creativity: a case study in madrasah. *10*(1), 101–112. https://doi.org/10.15575/jpi.v10i1.35207

Zulyusri, Z., Santosa, T. A., Festiyed, F., Yerimadesi, Y., Yohandri, Y., Razak, A., & Sofianora, A. (2023). Effectiveness of STEM Learning Based on Design Thinking in Improving Critical Thinking Skills in Science Learning: A Meta-Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 112–119. https://doi.org/10.29303/jppipa.v9i6.3709