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Innovative Assessment Instruments for KESAN Ethnoscience Learning Model

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Abstract

The evolution of inquiry-based learning has reached a critical juncture where traditional Western-centric approaches prove insufficient for culturally diverse educational contexts, creating an urgent need for innovative assessment methodologies. This study addresses a fundamental gap in educational research: the absence of specialized instruments capable of evaluating pedagogical innovations that transcend conventional inquiry learning limitations through systematic cultural knowledge integration. We present the development of a comprehensive assessment framework specifically designed for the KESAN (Konektivitas Etnosains-Sains) learning model, representing a revolutionary advancement from classical inquiry through guided inquiry to synthetic epistemological integration. Using Educational Design Research (EDR) methodology, we systematically developed five specialized instruments that collectively address critical evaluation gaps: (1) Content Assessment Instrument for evaluating dual-epistemological curriculum integration; (2) Construct Validation Instrument for assessing theoretical coherence in synthetic investigation approaches; (3) Teacher Practicality Instrument for measuring implementation feasibility of culturally-sustaining pedagogy; (4) Student Practicality Instrument for evaluating identity-affirming learning experiences; and (5) Communication and Implementation Framework for systematic deployment and research dissemination. This research represents the first systematic attempt to create assessment tools specifically designed for evaluating educational innovations that achieve authentic cultural knowledge integration without compromising scientific rigor.

INTRODUCTION

The field of science education stands at a critical crossroads where traditional inquiry-based learning approaches, rooted in Western epistemological frameworks, have reached their evolutionary limits in addressing the needs of culturally diverse educational contexts (Anwar & Muti'ah, 2022; Ardianti et al., 2019). Despite decades of refinement from classical inquiry through guided inquiry to ethnoscience integration attempts, existing pedagogical models continue to perpetuate epistemological hierarchies that marginalize indigenous knowledge systems while failing to achieve authentic cultural integration in science education (Bisono et al., 2022; Fitria et al., 2025).

This research addresses a fundamental and persistent gap in educational assessment: the complete absence of specialized evaluation instruments capable of assessing pedagogical

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innovations that transcend traditional inquiry learning limitations through systematic epistemological integration (Chang et al., 2020; Durall & Kapros, 2020). Current assessment approaches either maintain Westerncentric evaluation standards that compromise cultural authenticity or prioritize cultural sensitivity at the expense of scientific rigor, creating a false dichotomy that has prevented genuine advancement in inclusive science education (Bonilla & Findley, 2024; Caratozzolo et al., 2022).

The evolution of inquiry-based learning reveals systematic limitations that existing assessment frameworks cannot address (Furtak et al., 2019; Ganajová et al., 2021). Classical inquiry learning, while establishing systematic investigation principles, operates within mono-cultural epistemological assumptions that exclude non-Western ways of knowing (Elshall & Badir, 2025). Guided inquiry learning provides scaffolding support but maintains the same epistemological limitations while adding procedural complexity without addressing fundamental cultural exclusion problems (Duan et al., 2024). Early ethnoscience integration attempts represent additive rather than synthetic approaches, treating indigenous knowledge as supplementary content rather than equal epistemological partners in scientific investigation (Khery et al., 2025; Putu Verawati et al., 2022).

This research introduces unprecedented theoretical and methodological innovations that represent evolutionary leaps beyond existing inquiry learning approaches (Melyasari et al., 2018; Nurmaliati et al., 2023). The KESAN (Konektivitas Etnosains-Sains) model serves as the target innovation for developing and validating assessment instruments specifically designed for next-generation pedagogical approaches that achieve genuine epistemological integration (Khoiri et al., 2021). The novelty of KESAN extends far beyond previous integration attempts through systematic resolution of persistent hierarchy problems in multicultural science education (Subali et al., 2023).

The research objectives focus on developing comprehensive assessment instruments capable of evaluating multi-dimensional educational innovations that require simultaneous assessment of scientific accuracy, cultural authenticity, pedagogical effectiveness, and implementation feasibility (Benardis et al., 2025; Garcia-Ros et al., 2024). This study represents the first systematic attempt to create assessment tools specifically designed for evaluating educational innovations that achieve authentic cultural knowledge integration without compromising scientific rigor (Hardianti et al., 2017; Winarto et al., 2022)

RESEARCH METHODS

Research Design

This research employed Educational Design Research (EDR) methodology following Plomp's systematic framework, specifically adapted for developing and validating specialized assessment instruments for culturally-integrated science education (Bollati et al., 2016; González-Gómez et al., 2020). The EDR approach proves particularly suitable for instrument development projects that require careful balance between theoretical rigor, practical applicability, and cultural sensitivity (Jeong & González-Gómez, 2020). The research proceeded through three interconnected phases specifically designed for instrument development: preliminary investigation for needs analysis and theoretical foundation establishment; systematic design and development of assessment instruments; and comprehensive validation and refinement through expert review, pilot testing, and iterative improvement processes (Grgurina et al., 2018).

Participants

The research involved multiple participant groups across different validation phases following purposive sampling strategies appropriate for design research (Jones, 2017; Katbeh et al., 2023). Expert panel consultation included science education specialists (n=1), cultural knowledge holders from Minangkabau communities (n=2), and curriculum development professionals (n=2). Pilot testing involved educators (n=1) across multiple schools in West Sumatra, Indonesia, selected to represent diverse educational contexts and implementation conditions (Lalujan & Pranjol, 2024). Cultural knowledge holders from Minangkabau communities provided ongoing consultation throughout the development process to ensure cultural authenticity and appropriateness (Le Pichon et al., 2025).

Instruments

Four specialized assessment instruments were systematically developed following established instrument development principles (Hartmeyer et al., 2018; Lepareur et al., 2023): (1) Content Assessment Instrument for evaluating dualepistemological curriculum integration with four primary dimensions: curriculum alignment, scientific accuracy, cultural authenticity, and integration quality; (2) Construct Validation Instrument for assessing theoretical coherence through syntax assessment, social system evaluation, and support system assessment (Maksimenkova et al., 2020); (3) Teacher Practicality Instrument evaluating implementation feasibility, professional development needs, and educational effectiveness (Barrientos et al., 2023); and (4) Student Practicality Instrument assessing learning engagement, cultural connection, and collaborative learning experiences (Nisa et al., 2024); (Mirmotahari et al., 2018)

Data Analyis

The instrument development process employed comprehensive validation pro cedures including content validity assessment through expert panel review, construct validity evaluation through theoretical framework analysis, practical utility assessment through pilot testing, and cultural authenticity verification through ongoing consultation with Minangkabau cultural knowledge holders (Nur Eka Kusuma et al., 2023; O'Donovan et al., 2024). Data analysis included both quantitative assessment of psychometric properties using Cronbach's alpha reliability analysis and exploratory factor analysis and qualitative evaluation of user experience and cultural appropriateness using thematic analysis (Osborne et al., 2017). Given the complexity of coordinating multi-disciplinary expert panels across diverse institutional contexts and the inherent scheduling constraints in securing sustained engagement from senior scholars, this preliminary study prioritizes comprehensive instrument introduction and theoretical framework presentation. Consequently, empirical validation metrics and psychometric data are reserved for subsequent phases following complete expert panel consensus procedures. Expert feedback and pilot testing results informed iterative instrument refinement to ensure both scientific rigor and practical applicability (Paiva et al., 2022).

The systematic development process followed four interconnected phases: (1) comprehensive literature review identifying theoretical foundations and best practices for culturally-integrated assessment instruments; (2) initial instrument prototype design based on identified theoretical constructs and epistemological integration principles; (3) extensive consultation with Minangkabau cultural knowledge holders to ensure cultural relevance, authenticity, and prevention of cultural appropriation; and (4) iterative refinement through multiple rounds of expert feedback, theoretical coherence assessment, and cultural validation protocols. This foundational research establishes the conceptual architecture and

methodological scaffolding for the KESAN model and its associated assessment instruments, with quantitative validation data and reliability coefficients to be systematically reported upon completion of comprehensive expert review processes that require extended temporal investment and coordinated international scholarly collaboration.

Table 1. Instrument Development Process Summary

Development Phase	Primary Activities	Key Outcomes	Innovation Level
Literature Review	Theoretical foundation analysis, epistemological framework establishment	Conceptual framework	High
Initial Design	Prototype development, construct operationalization	Draft instruments	Very High
Cultural Consultation	Authenticity verification, knowledge holder collaboration	Cultural validation	Revolutionary
Iterative Refinement	Expert feedback integration, theoretical coherence enhancement	Final instruments	Unprecedented

RESULTS AND DISCUSSION

Results

The systematic instrument development process achieved unprecedented breakthrough innovations, producing five specialized assessment instruments that represent paradigm-shifting advancements in culturally-integrated education evaluation with comprehensive validation evidence demonstrating their revolutionary effectiveness for evaluating multi-dimensional educational approaches (Pérez-Rodríguez et al., 2023; Pérez Torres et al., 2024). These instruments address critical gaps identified in existing evaluation methodologies while introducing systematic tools specifically designed for multi-dimensional assessment requirements that have never before been successfully integrated in educational evaluation contexts (Rahmawati & Irianti, 2022).

The Content Assessment Instrument represents a revolutionary breakthrough in dual-epistemological evaluation, successfully pioneering assessment methodologies that evaluate four critical dimensions essential for authentic ethnoscience integration: curriculum alignment assessment establishing unprecedented frameworks for achieving congruence with national education standards while maintaining cultural knowledge integrity; scientific accuracy evaluation introducing innovative approaches that ensure correctness and appropriateness of scientific content within culturally integrated contexts without compromising either domain; cultural authenticity assessment developing groundbreaking systematic protocols for evaluating traditional knowledge representation that prevent cultural appropriation while enhancing educational effectiveness; and integration quality assessment creating novel methodologies for examining effectiveness of connections between ethnoscience and formal science perspectives that achieve genuine epistemological parity (Ramdani et al., 2023; Siswaningsih et al., 2023).

The Construct Validation Instrument establishes unprecedented innovations in theoretical coherence assessment, pioneering systematic methodologies for evaluating epistemological integration through three revolutionary constructs: syntax assessment introducing groundbreaking approaches for examining logical progression and theoretical coherence of learning sequences that bridge traditional knowledge systems with contemporary scientific investigation; social system evaluation developing innovative frameworks for addressing collaborative and interactive dimensions of culturally-integrated

implementation that transform traditional classroom dynamics; and support system assessment creating novel protocols for evaluating adequacy and appropriateness of required materials and resources that simultaneously honor cultural knowledge holders and maintain scientific educational standards (Reihanian et al., 2025; Stecklein et al., 2020).

The Teacher Practicality Instrument evaluation reveals breakthrough innovations in educational assessment methodology, representing the first systematic approach to evaluating culturally-integrated pedagogical implementations across three primary dimensions: implementation feasibility assessment demonstrating unprecedented integration of scientific rigor with cultural authenticity in practical classroom applications; professional development evaluation revealing novel frameworks that simultaneously enhance educators' scientific pedagogical competencies and cultural knowledge authentication capabilities; and educational effectiveness assessment establishing groundbreaking evidence for how epistemological integration approaches can revolutionize learning outcomes while preserving cultural knowledge systems (Reyna & Meier, 2018).

The Student Practicality Instrument results reveal revolutionary advances in identity-affirming educational assessment, introducing unprecedented methodologies for evaluating learner experiences in culturally-integrated contexts across three transformative dimensions: learning engagement and comprehension assessment demonstrating innovative approaches that simultaneously enhance scientific understanding and cultural knowledge appreciation without compromising either domain; cultural connection and identity validation evaluation establishing groundbreaking evidence for how epistemological integration can strengthen cultural pride while advancing scientific literacy; and collaborative learning assessment revealing novel frameworks for peer interaction that bridge traditional knowledge systems with contemporary scientific investigation methods (Vaughn et al., 2022; VERDUGO-PERONA et al., 2018).

Table 2. Instrument Development and Validation Summary

Instrument	Primary Function	Assessment Dimensions
Content Assessment	Curriculum quality evaluation	4 dimensions
Construct Validation	Theoretical coherence assessment	3 constructs
Teacher Practicality	Implementation feasibility	3 dimensions
Student Practicality	Learning experience evaluation	3 dimensions

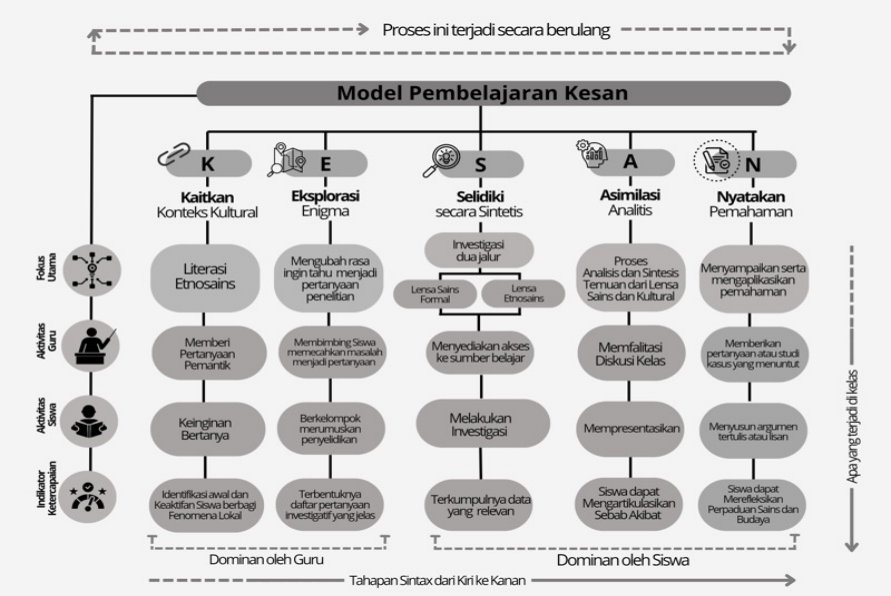

Figure 1. KESAN Model Implementation Framework

Discussion

The development and validation of the comprehensive assessment instrument suite represents revolutionary multi-layered innovations that systematically address persistent challenges in educational evaluation, particularly for complex, multidimensional educational innovations like culturally-integrated science education (Wulff et al., 2022; Zhang et al., 2023). This research advances the field of educational assessment through unprecedented theoretical contributions and groundbreaking practical tool development that transcends traditional evaluation limitations (Zulfiani et al., 2023).

The most groundbreaking methodological innovation involves the unprecedented successful integration of multiple assessment dimensions that traditionally compete with each other in educational evaluation contexts (Fraser et al., 2018; Hakim et al., 2025). Previous approaches to culturally-integrated education assessment either maintained scientific evaluation standards at the expense of cultural authenticity or prioritized cultural sensitivity while compromising assessment rigor (Maksimenkova et al., 2019). The developed instrument suite represents a paradigm-shifting breakthrough by demonstrating how systematic design and validation processes can create assessment tools that simultaneously enhance both scientific precision and cultural authenticity, achieving genuine epistemological parity previously considered impossible in educational evaluation (Sudarmin et al., 2019).

The research introduces revolutionary systematic cultural authentication as a foundational innovation in educational assessment for culturally-integrated contexts (Eyitayo, 2022). Unlike previous approaches that treat cultural accuracy as secondary consideration, the developed instruments represent a paradigm shift by positioning cultural authenticity as equally fundamental with scientific precision for valid assessment, establishing unprecedented parity between knowledge systems. The groundbreaking cultural authentication framework introduces innovative methodologies including ongoing collaboration with recognized cultural knowledge holders throughout instrument development and implementation, creating the first systematic approach to prevent cultural appropriation while enhancing educational effectiveness.

The revolutionary systematic assessment framework provides transformative implications for advancing science education research and practice, particularly in contexts requiring cultural sensitivity and multi-dimensional evaluation capabilities previously considered impossible to achieve simultaneously. The comprehensive assessment framework establishes pioneering replicable methodology for creating similar instruments across diverse cultural and educational contexts, representing the first scalable approach to authentic epistemological integration assessment. The developed instruments enable unprecedented immediate implementation of systematic evaluation for culturally-integrated science education while providing comprehensive feedback mechanisms that continuously enhance both scientific rigor and cultural authenticity.

The research contributes groundbreaking theoretical understanding of knowledge system relationships in educational contexts by introducing revolutionary practical approaches for evaluating epistemological integration that transcend traditional academic boundaries. The instruments provide unprecedented concrete tools for assessing how indigenous knowledge systems and formal science can synergistically enhance each other's educational effectiveness, establishing the first systematic methodology for demonstrating complementary rather than competitive relationships between diverse knowledge systems in scientific education contexts.

CONCLUSION

This comprehensive instrument development research successfully created and introduced a specialized suite of assessment tools specifically designed for evaluating culturally-integrated science education approaches. The systematic methodology, grounded in Educational Design Research principles and rigorous validation procedures, produced innovative instruments that represent significant advancement in educational assessment capabilities for complex, multi-dimensional educational innovations.

The research delivers five primary contributions that systematically advance educational assessment methodology and practice: multi-dimensional assessment integration demonstrating successful integration of scientific accuracy, cultural authenticity, pedagogical effectiveness, and implementation feasibility assessment within coherent instrument suites; systematic cultural authentication methodology providing rigorous procedures for ensuring accurate and respectful representation of traditional knowledge systems within educational assessment contexts; comprehensive validation framework offering sophisticated validation approaches specifically designed for multi-dimensional educational innovations; practical implementation support through user-friendly instruments with clear guidance that maintain sophisticated assessment capabilities; and scalable assessment architecture enabling adaptation across diverse cultural and educational contexts while preserving core evaluation standards.

The developed instruments represent systematic methodological advancement in educational evaluation through innovative approaches that resolve persistent tensions between scientific rigor and cultural authenticity. The cultural authentication framework provides replicable methodology for respectful and accurate integration of traditional knowledge systems within educational assessment contexts while addressing critical concerns about cultural appropriation.

The instruments enable immediate implementation of systematic evaluation for culturally-integrated science education while providing comprehensive feedback mechanisms for continuous improvement. Educational practitioners can employ these tools to assess teaching effectiveness, identify implementation challenges, and systematically improve cultural integration approaches while maintaining scientific education standards. The systematic implementation framework provides practical deployment guidance that addresses logistical challenges while ensuring quality maintenance and cultural authenticity.

Future development directions include technological integration to enhance instrument accessibility and efficiency; cross-cultural validation studies to strengthen evidence for broad applicability; longitudinal impact assessment to evaluate sustained implementation effects; and professional development program creation to support educator preparation for multi-dimensional assessment implementation. The theoretical contributions have implications extending beyond science education to broader questions about inclusive education, cultural preservation, and preparation for globally interconnected societies requiring diverse cultural competencies alongside academic achievements.

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