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ORIGINAL

Development of a Think Pair Share Model Integrated with Scientific and Ethnoscience Approaches

Desarrollo de un modelo Think Pair Share integrado con enfoques científicos y etnocientíficos

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ABSTRACT

Contemporary biology education requires student-centered approaches that foster critical thinking, inquiry, and contextual learning, particularly through the integration of scientific and ethnoscience frameworks to address the limitations of traditional teacher-centered methods. This study aimed to develop and validate a Think Pair Share (TPS) learning model that combined scientific and ethnoscience approaches to enhance students' critical thinking skills and conceptual understanding in higher education biology. The research employed a Research and Development (R&D) design based on the ADDIE framework and was conducted through expert validation of content, language, and instructional design, followed by implementation using a quasi-experimental design with control and experimental groups. Data were collected through observations, questionnaires, and pre- and post-tests and were analyzed using descriptive statistics, Aiken's V, and t-tests. The findings showed that the model, which consisted of a guidebook, lecturer's handbook, and student workbook, achieved high validity and practicality ratings and produced significant improvements in students' critical thinking compared to the control group ($p < 0,05$). The study concluded that the model was effective in fostering active and culturally relevant learning and recommended further research to examine its scalability and potential digital integration.

Keywords: Think Pair Share; Scientific Approach; Ethnoscience; Biology Education; Critical Thinking.

RESUMEN

La enseñanza contemporánea de la biología requería enfoques centrados en el estudiante que fomentaran el pensamiento crítico, la indagación y el aprendizaje contextual, particularmente mediante la integración de marcos científicos y etnocientíficos para superar las limitaciones de los métodos tradicionales centrados en el docente. Este estudio tuvo como objetivo desarrollar y validar un modelo de aprendizaje Think Pair Share (TPS) que combinara los enfoques científico y etnocientífico para mejorar las habilidades de pensamiento crítico y la comprensión conceptual de los estudiantes en la educación superior en biología. La investigación empleó un diseño de Investigación y Desarrollo (I+D) basado en el marco ADDIE y se llevó a cabo mediante la validación por expertos del contenido, el lenguaje y el diseño instruccional, seguida de la implementación con un diseño cuasi-experimental con grupos control y experimental. Los datos se recopilaron mediante observaciones, cuestionarios y pruebas previas y posteriores, y se analizaron con estadísticas descriptivas, el índice V de Aiken y pruebas t. Los resultados mostraron que el modelo, compuesto por un manual guía, un manual para docentes y un cuaderno de trabajo para estudiantes, alcanzó altos índices de validez y practicidad y produjo mejoras significativas en el pensamiento crítico de los estudiantes en comparación con el grupo de control ($p < 0,05$). Se concluyó que el modelo fue eficaz para promover un aprendizaje activo y culturalmente relevante, y se recomendó realizar investigaciones adicionales para examinar su escalabilidad y posible integración digital.

Palabras clave: Think Pair Share; Enfoque Científico; Etnociencia; Enseñanza de la Biología; Pensamiento Crítico.

INTRODUCTION

The twenty-first century demands a transformation in science education, particularly biology, which now requires students to master cognitive content while actively engaging in inquiry, contextual problem-solving, and critical thinking.[1,2,3,4,5,6] In Indonesia, this educational vision aligns with Law No. 20 of 2003 on the National Education System, which emphasizes holistic learning that nurtures creativity, autonomy, and scientific curiosity.[7,8,9,10] Biology, rooted in the Greek words *bios* (life) and *logos* (knowledge), represents not only a collection of facts but also a discipline that cultivates reasoning, interpretation, and evaluation of natural phenomena. As such, effective biology learning must integrate theoretical, practical, ethical, and contextual dimensions to meet twenty-first-century competencies.[11]

Contemporary research underscores that student-centered, contextually engaging pedagogies produce stronger learning outcomes than traditional lecture-based instruction. Models such as resource-based and project-based learning have improved students' motivation, performance, and attitudes,[12,13] while laboratory-based and community-linked projects have deepened conceptual understanding through authentic inquiry.[14] These innovations also respond to post-pandemic shifts toward digitalized and interactive learning environments that require flexibility and differentiated engagement.[15,16] Despite these advances, many students continue to exhibit difficulties in connecting abstract biological concepts with real-life contexts, reflecting the need for pedagogical designs that blend scientific literacy with sociocultural relevance.[17,18,19,20]

The Think Pair Share (TPS) model, first proposed by Lyman, exemplifies this learner-centered transformation by promoting structured cooperation through three key phases: *think*, *pair*, and *share*.[21,22,23] These stages stimulate independent reflection, peer dialogue, and collective synthesis, effectively fostering higher-order thinking, confidence, and communication skills.[24,25] Empirical findings demonstrate that TPS enhances motivation, engagement, and knowledge retention compared with conventional approaches.[26,27] When integrated with inquiry-based learning, TPS provides a scaffold for meaningful collaboration and reflection in the sciences.

Complementing this, the scientific approach, which includes observing, questioning, experimenting, associating, and communicating, fosters empirical reasoning and disciplined investigation. It enables students to construct understanding through active observation and testing. However, successful implementation depends on sufficient classroom time and teacher expertise. Within a socio-constructivist framework, structured facilitation during inquiry has been found to sustain engagement and reduce uncertainty.

Equally important is the ethnoscience approach, which links scientific content with local culture and indigenous knowledge systems. This perspective situates learning within students' social and ecological contexts, improving ecological literacy and inclusive participation. Ethnoscience urges educators to begin from the "known", students' lived experiences and cultural practices, before advancing to scientific abstraction. It also encourages environmental stewardship and validates diverse epistemologies in science education.

Integrating TPS, scientific, and ethnoscience approaches creates a holistic framework that balances inquiry-driven learning with cultural grounding. In this structure, the "think" phase aligns with observation and reflection on local phenomena; the "pair" phase involves questioning and analyzing cultural contexts collaboratively; and the "share" phase emphasizes association and communication, allowing students to synthesize cultural and scientific perspectives. This pedagogical synthesis not only cultivates critical and collaborative competencies but also reinforces the value of cultural wisdom in scientific reasoning.

Therefore, this study aimed to develop and validate a Think Pair Share (TPS) model integrated with scientific and ethnoscience approaches to enhance students' critical thinking skills and conceptual understanding in higher education biology. Specifically, it addressed two key questions:

1. How can such an integrated TPS model be designed effectively for higher education biology learning?
2. What are the characteristics of a valid, practical, and effective TPS model for improving students' critical thinking?

By addressing these questions, the study contributes to advancing biology pedagogy through a contextually responsive model that unites scientific inquiry and cultural knowledge, thereby fostering both scientific literacy and sociocultural awareness among twenty-first-century learners.

METHOD

Research Design

This study employed a research and development (R&D) design aimed at creating and validating a *Think Pair Share (TPS)* instructional model integrated with scientific and ethnoscience approaches to enhance students' critical thinking in biology education. The development followed the ADDIE framework, consisting of five sequential phases: Analyze, Design, Develop, Implement, and Evaluate. This model is widely applied in instructional design to develop evidence-based teaching strategies, learning media, and materials that ensure pedagogical coherence and iterative refinement.

Development Procedures

Analysis

The initial analysis identified pedagogical gaps in current biology instruction through classroom observations, document analysis, and semi-structured interviews with lecturers and students. Data collection aligned with higher education learning outcomes and focused on conceptual mastery, critical thinking, and contextual problem-solving. To curate *cultural and ethnoscientific content*, a community engagement process was conducted involving local experts, traditional practitioners, and cultural leaders from the Riau and East Java regions. Through focused group discussions and ethnographic consultations, indigenous practices, such as ecological conservation, herbal medicine preparation, and local agricultural wisdom, were reviewed and validated for scientific relevance. These consultations ensured ethical integration of local cultural knowledge within the scientific framework, in line with ethnographic protocols emphasizing participatory validation and contextual authenticity.

Design

The design phase established the structural alignment between TPS, scientific, and ethnoscience learning components. The model was contextualized to Indonesia's higher education curriculum standards and structured to promote critical thinking, inquiry, and sociocultural awareness. Learning activities were developed to allow students to connect biological concepts with real-life and indigenous contexts through cooperative and reflective engagement.

Development

A prototype TPS model was developed in three formats: (1) Model Book, (2) Instructor's Guide, and (3) Student Workbook. Each component was aligned with course syllabi and learning outcomes. Expert validation was conducted by five specialists in biology education, curriculum design, and cultural studies, who assessed theoretical coherence, content validity, and pedagogical feasibility. The Aiken's V coefficient was employed to determine the validity of the instruments and model components, using a threshold of $V \geq 0{,}667$ to indicate acceptable agreement among experts. This approach has been reaffirmed in recent validation studies as a reliable quantitative index for expert judgment analysis.

Implementation

The validated model was implemented at two universities representing contrasting academic contexts: one categorized as a "high-level" institution and another as a "low-level" institution. This categorization was operationalized based on accreditation rankings (BAN-PT), average national test performance (SN-Dikti data), and institutional resources (laboratory and ICT facilities). A quasi-experimental design was adopted, using non-randomized control group pre-test and post-test methodology to evaluate the model's effectiveness. Participants were selected using purposive sampling from intact classes that shared equivalent course structures. Group assignment was conducted at the classroom level rather than individual randomization to maintain ecological validity and instructional consistency. The experimental group received the developed TPS-integrated model, while the control group received traditional lecture-based instruction.

Evaluation

Evaluation was conducted at both **process** and **outcome** levels. Process evaluation assessed lecturers' fidelity of implementation using observation checklists, while outcome evaluation measured students' improvements in critical thinking and engagement. The model was considered effective if it met the validity and practicality criteria and demonstrated a "good" or higher improvement rating in post-test performance.

Data Collection

Data were collected through both qualitative and quantitative techniques.

- Qualitative data included field notes, classroom observations, interviews, and focus group discussions with students, lecturers, and cultural informants.
- Quantitative data were gathered using structured instruments, including:
    1. Needs analysis questionnaires for baseline instructional diagnosis.
    2. Expert validation forms for evaluating the model, guidebook, and workbook.
    3. Practicality questionnaires assessing ease of use and contextual applicability.

4. Effectiveness tests and questionnaires measuring motivation, engagement, and learning outcomes.

Instrument development followed a rigorous process of blueprinting, item formulation, expert validation, pilot testing, and empirical refinement to ensure internal consistency and construct alignment.

Data Analysis

Data analysis combined qualitative and quantitative methods:

- Qualitative data were analyzed through thematic coding, reduction, and triangulation to identify key patterns in cultural integration and instructional dynamics.
- Quantitative data analysis included:
    1. Aiken's V for content validity.
    2. Cronbach's Alpha for reliability ($\alpha \geq 0{,}70$).
    3. Likert-scale descriptive statistics for practicality.
    4. Kolmogorov–Smirnov tests for normality and Levene's tests for homogeneity.
    5. Independent-sample t-tests to determine the significance of mean differences in pre-test and post-test scores between control and experimental groups.

All statistical computations were conducted using SPSS version 20.0, adhering to the Ministry of Education's research standards and interpretation rubrics for instructional effectiveness.

RESULTS

This study aimed to develop a *Think Pair Share (TPS)* instructional model integrated with scientific and ethnoscience approaches to enhance students' critical thinking skills in biology education. The model development process followed the ADDIE framework, Analyze, Design, Develop, Implement, and Evaluate. The findings from each phase are presented below, supported by systematically numbered tables.

Analysis Phase

The initial analysis revealed a substantial gap between the intended learning outcomes of biology education and classroom realities. Observations and questionnaires indicated that instruction remained largely teacher-centered, resulting in low student engagement and minimal incorporation of cultural or ethnoscientific elements. Students exhibited limited ability to apply biological concepts critically and contextually, underscoring the need for a more inquiry- and culture-based model.

Table 1. Key Findings from Needs Analysis

Indicator	Result
Student critical-thinking level	Low
Use of local context/ethnoscience in lessons	Rare
Lecturer support for new instructional models	High
Student preference for collaborative learning	High

Design Phase

Based on the analytical findings, a TPS instructional model was designed by integrating steps from both scientific and ethnoscience approaches. The resulting structure emphasized curriculum alignment, critical thinking, and contextual relevance.

- TPS Steps: Think – Pair – Share.
- Scientific Steps: Observing, Questioning, Experimenting, Associating, Communicating.
- Ethnoscience Integration: linking concepts with local culture, environmental practices, and traditional ecological knowledge.

This integrated structure provided a balanced framework that connected scientific inquiry with sociocultural realities.

Development Phase

The TPS-based learning model was developed into three validated learning resources: a Model Book, an Instructor's Guidebook, and a Student Workbook. Each component underwent expert validation using a five-point Likert scale, analyzed through Aiken's V. All items exceeded the minimum validity coefficient of 0,667, confirming strong inter-expert agreement.

Table 2. Validation Results of Learning Resources		
Component	**Mean ± SD**	**Category**
Model Book	4,75 ± 0,08	Very Valid
Instructor's Guidebook	4,60 ± 0,10	Very Valid
Student Workbook	4,68 ± 0,09	Very Valid

Implementation Phase

The validated model was implemented at two universities categorized as high-level and low-level institutions. A quasi-experimental design (non-randomized control group pre-test-post-test) was applied. Students in the experimental group received instruction using the developed TPS model, while the control group followed traditional lecture-based methods.

Table 3. Average Critical-Thinking Scores (Mean ± SD) in Control and Experimental Groups		
University Type	**Control Group (Pre → Post)**	**Experimental Group (Pre → Post)**
High-Level	62 ± 5,1 → 68 ± 6,2	63 ± 5,4 → 80 ± 5,8
Low-Level	58 ± 4,7 → 65 ± 5,5	59 ± 5,0 → 76 ± 6,1

Students in the experimental group demonstrated significantly higher gains in post-test scores ($p < 0,05$), confirming the effectiveness of the TPS-integrated model in improving critical-thinking performance across institutional contexts.

Evaluation Phase

Evaluation involved triangulated data from student and lecturer questionnaires, classroom observations, and test results. The model was rated "high" to "very high" in practicality and engagement. Statistical analysis indicated the model's overall effectiveness at 85 %, with strong motivational and interactive outcomes.

Table 4. Effectiveness Evaluation Results (Mean ± SD)		
Evaluation Aspect	**Mean ± SD**	**Category**
Motivation	3,70 ± 0,45	High
Engagement	3,85 ± 0,38	Very High
Model Effectiveness	85 % ± 4,2	Good

The post-test *t*-test analysis revealed a statistically significant improvement ($p < 0,05$) in critical-thinking skills among students taught using the TPS model compared with those in conventional classes. Instrument reliability and validity were further confirmed via Cronbach's Alpha ≥ 0,70 and Aiken's V ≥ 0,667 thresholds.

DISCUSSION

Design of a Think-Pair-Share (TPS) Model Integrated with Scientific and Ethnoscience Approaches

The development of the *Think-Pair-Share (TPS)* model integrated with scientific and ethnoscience approaches was grounded in a comprehensive analysis of curriculum expectations, learner profiles, and classroom realities within higher education biology programs at Universitas Lancang Kuning. The analysis revealed a persistent gap between intended learning outcomes and actual student performance, particularly in conceptual understanding and critical thinking. Quantitative findings from the pre- and post-tests (table 3) support this gap, showing mean gains of +18 points (SD ± 5,8) for students at high-level institutions and +17 points (SD ± 6,1) at low-level institutions following TPS-based instruction.

These results empirically confirm that the integrated TPS framework effectively enhances students' critical-thinking capacity and contextual reasoning, surpassing the improvements achieved under conventional instruction ($p < 0,05$). Such gains align with prior evidence that structured peer interaction and cooperative inquiry promote higher-order cognitive engagement.[24,25] By encouraging reflection during the *think* phase, negotiation of meaning in the *pair* phase, and public reasoning in the *share* phase, the TPS cycle fosters conceptual depth, participation, and self-efficacy.[26,27,28]

The integration of ethnoscience into this cooperative structure further enriched the learning context by connecting biological phenomena to culturally grounded experiences.[29] This approach strengthened students' ability to interpret abstract scientific ideas through familiar ecological and community-based practices, leading to more meaningful conceptual internalization. Previous studies in science and STEM education have similarly reported that combining TPS with culturally or contextually relevant learning enhances both motivation and comprehension.(30,31,32)

Rather than relying solely on the theoretical postulates of concept mastery proposed by Hamalik and Syafei, the present findings substantiate these pedagogical assumptions through empirical evidence from pre- and post-test **data**.(33,34,35,36,37,38) The measured improvements in conceptual mastery and critical thinking demonstrate that the TPS-scientific-ethnoscience integration yields observable cognitive and attitudinal benefits within authentic learning environments.(39,40,41,42,43,44)

Moreover, the model's alignment with the five scientific learning stages, observing, questioning, experimenting, associating, and communicating, creates a coherent inquiry sequence consistent with the *Kementerian Pendidikan dan Kebudayaan* standards. Empirical and comparative studies(45,46) corroborate that embedding these stages within cooperative and culturally responsive tasks enhances inquiry skills, analytical reasoning, and ecological awareness.(47,48,49)

Characteristics of the Integrated TPS Model: Valid, Practical, and Effective

The validated TPS model underwent rigorous review and field testing to confirm its **validity, practicality, and effectiveness**. Expert evaluation produced very high validity scores across components, model book (4,75 ± 0,08), instructor's guidebook (4,60 ± 0,10), and student workbook (4,68 ± 0,09), each exceeding the Aiken V ≥ 0,667 criterion.(50,51,52,53) These findings confirm that the instructional tools achieved strong agreement among specialists in biology education and curriculum design.

Implementation trials demonstrated high feasibility and positive reception among lecturers and students. Classroom observations indicated active participation, sustained peer engagement, and improved scientific argumentation during TPS sessions. The increase in post-test critical-thinking scores and high motivation ratings (Mean = 3,70 ± 0,45) support the model's pedagogical impact.

These empirical outcomes reinforce previous evidence that TPS enhances cooperation, reflection, and higher-order thinking.(18,54,55) The integration of scientific and ethnoscience components proved particularly valuable: the scientific element developed analytical and empirical reasoning, while the ethnoscience component grounded learning in culturally meaningful contexts, increasing motivation and relevance.(56,57,58,59) This dual structure thus bridges cognitive and affective learning domains, yielding a more holistic educational experience.(60,61,62)

Study Limitations

While the results demonstrate strong validity and effectiveness, several limitations should be acknowledged.

1. Sample scope, the quasi-experimental design involved only two universities; therefore, generalization to other regions or disciplines should be made cautiously.
2. Non-random group assignment, Because intact classes were used, potential pre-existing differences between groups could have influenced outcomes despite comparable baseline means.
3. Short-term assessment, the evaluation measured immediate post-test gains; long-term retention of critical-thinking improvements was not examined.
4. Cultural variability, ethnoscientific content was curated from local contexts (Riau and East Java); replication in other cultural settings may require contextual adaptation.

Acknowledging these constraints, future research should include randomized sampling, longitudinal assessment, and broader cultural validation to enhance the external reliability of the integrated TPS framework.

CONCLUSIONS

This study concludes that the *Think Pair Share (TPS)* model integrated with scientific and ethnoscience approaches effectively addresses challenges in higher education biology learning by combining cooperative strategies with culturally contextualized knowledge. The model's novelty lies in bridging scientific inquiry with local wisdom, creating meaningful learning experiences that enhance critical thinking, conceptual mastery, and student engagement. Validation and implementation confirmed the model's validity, practicality, and effectiveness, highlighting its potential to transform biology education toward learner-centered paradigms that promote both cultural appreciation and scientific literacy.

However, several limitations should be acknowledged. First, the quasi-experimental design utilized non-randomized class groups, which may limit causal generalization despite efforts to ensure baseline equivalence. Second, the study involved only two universities, potentially restricting representativeness across diverse institutional contexts. Third, the evaluation focused primarily on short-term cognitive outcomes, without assessing long-term retention or transfer of critical-thinking skills. Lastly, the ethnoscientific content was drawn from local contexts in Riau and East Java, requiring cultural adaptation for broader application.

Recognizing these constraints, future research should incorporate randomized sampling, larger and more

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varied populations, longitudinal designs, and cross-cultural validation. Such extensions will strengthen the generalizability and sustainability of the integrated TPS framework, as well as explore its digital and interdisciplinary adaptability across other STEM disciplines.

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