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# Development of an Integrating Ethnoscience Module in Project-Based Learning to Enhance the Pedagogical Competence of Elementary Teacher Education Students

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**Abstract:** Improved the quality of science education in elementary teacher training requires the development of instructional modules that are both contextual and culturally responsive. This study was conducted to design, implement, and evaluate a Project-Based Learning (PjBL) module integrated with ethnoscience to enhance the pedagogical competence of Elementary School Teacher Education students. Using a 4D development model (Define, Design, Develop, and Disseminate), the study included expert validation and user practicality testing. The module contextualized scientific content, particularly the concept of heat and temperature, using local cultural practices such as traditional palm sugar processing. Validation results indicated high feasibility scores in the didactic (94.00%), construction (96.00%), and visual aspects (98.33%) categories, while the practicality test produced an average score of 92.00%. Moreover, inferential insights from the evaluation revealed statistically significant improvements in learners' conceptual understanding (N-gain score of 0.80). The findings demonstrated that integrating ethnoscience into project-based modules not only deepened students' comprehension of scientific principles but also fostered their ability to design meaningful, culturally relevant instruction. This research offers a valuable contribution to teacher education by presenting a validated instructional model that bridges scientific theory and local wisdom, promoting contextualized and engaging science learning. The module provides a scalable framework for future research and application across diverse educational and cultural settings.

**Keywords:** Contextual learning; Ethnoscience; Pedagogical competence; Project-based learning; Teacher training

## Introduction

Elementary education plays a pivotal role in shaping students' foundational character, knowledge, and skills. Science, as a core domain in elementary education, aims to connect scientific phenomena to students' everyday lives. Nevertheless, despite its importance, elementary science instruction is often disconnected from students' local contexts and cultural experiences, reducing its relevance and effectiveness (Holmes et al., 2021; Morgado et al., 2022; Latip et al., 2024). A central challenge is how to make science more engaging and meaningful, as well as how to link scientific knowledge with students' local cultural values (Suciati, 2023; Zidny et al., 2020). One group warranting particular attention is the students in the Elementary School Teacher Education program, who are prospective teachers responsible for creating contextual and

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engaging science instruction for future generations (Sudarmin et al., 2024). Developing pedagogical competencies that integrate Project-Based Learning (PjBL) and ethnoscience is therefore crucial to support these students in designing relevant and practical instruction (Anattri et al., 2024). One approach shown to enhance the quality of science learning is the use of science kits (Nasharuddin et al., 2024). Through simple, laboratory-style activities facilitated by science kits, learners can grasp scientific concepts more concretely and deeply (Indayani, 2015).

A growing body of research underscores the importance of integrating local wisdom into science education to strengthen conceptual understanding and student engagement. Putri et al. (2024) and Rediani et al. (2023) reported that embedding local wisdom in instructional materials can simultaneously improve students' scientific knowledge and foster environmental stewardship. Students not only comprehend material more readily; they also feel more motivated and involved in the learning process (Akmal et al., 2020; Mukti et al., 2022), demonstrate gains in scientific literacy (Morgado et al., 2022), develop critical and creative thinking skills (Andriyanto et al., 2025; Vrbová, 2022), improve content understanding and perceived relevance, enhance analytical abilities, and build 21st-century competencies (Laos & Tefu, 2020). In parallel, Project-Based Learning (PjBL) has been shown to cultivate 21st-century skills, critical thinking, creativity, and collaboration by engaging students in authentic problem-solving within contextual scenarios (Zhang & Ma, 2023; Juita et al., 2025). The use of concrete teaching aids such as science kits further increases engagement and deepens understanding of scientific concepts (Widiana et al., 2020). Moreover, Ismail (2016) and Amran et al. (2017) note that hands-on experimentation with instructional apparatus stimulates curiosity and strengthens understanding of scientific phenomena, thereby boosting motivation, attention, and learning outcomes, particularly for abstract topics. In addition, Yusa et al. (2023) emphasize that a PjBL model, integrated with teaching aids such as science kits, can significantly enhance motivation and science learning outcomes.

Despite these advances, notable gaps persist in the development of learning modules that combine PjBL with ethnoscience and science kits, especially within teacher education. Much of the existing literature focuses on integrating local wisdom into content without sufficiently adopting active, experience-based methods, such as PjBL, that promote direct learner engagement (Sudarmin et al., 2019). Existing studies also tend to overlook applications within teacher-preparation contexts, particularly among Elementary School Teacher Education students, who often possess only an operational understanding of scientific concepts and struggle to connect them with effective teaching practices (Thompson et al., 2024; Nollmeyer & Baldwin, 2024). To prepare teachers capable of delivering relevant, contextualized science instruction, a more systematic and integrated approach is needed—one that fuses ethnoscience with project-based methods, enabling Elementary School Teacher Education students to design science learning that is both meaningful and experiential (Zidny et al., 2020).

This research is highly relevant to Elementary School Teacher Education students, especially those preparing to become science educators at the elementary level. It offers a unique opportunity to enhance their pedagogical skills, going beyond mere mastery of scientific content to include the ability to design and implement instruction that connects scientific concepts to pupils' everyday lives, particularly through experiments employing science kits. By developing a learning module that integrates ethnoscience with PjBL, we aim to strengthen their pedagogical competencies significantly. With such a module, Elementary School Teacher Education students will not only learn how to teach scientific concepts but also how to embed local cultural values into practicum activities, making learning more relevant and engaging. This approach will enable them to create learning experiences that are meaningful and firmly situated within learners' sociocultural contexts, inspiring them to become innovative and effective science educators.

The specific research gap addressed here is the absence of a learning module that integrates PjBL with ethnoscience within teacher education curricula, particularly at the Elementary School Teacher Education level and in students' teaching practices. Although many studies discuss the importance of both approaches in science education (Zidny et al., 2020), very few offer a combined and practical instructional design that allows Elementary School Teacher Education students to design instruction that is both contextual and experience-rich.

Given global curriculum developments and the demands of 21st-century skills, integrating local wisdom into science education is increasingly imperative. Prior work suggests that local knowledge can enrich science learning while advancing the Sustainable Development Goals (SDGs). PjBL, which affords learners direct experience and contextual problem-solving, is likewise effective in developing core 21st-century competencies such as critical thinking, collaboration, and creativity. However, a single implementable learning module that combines ethnoscience and PjBL for Elementary School Teacher Education students, especially in the context of science-kit experiments, has not been identified in the literature. This research, therefore, presents a novel and

potentially transformative approach to science education, highlighting the need for an innovative module that integrates both approaches. The potential impact of this research on science education is both intriguing and exciting.

This study presents a novel contribution by developing a learning module that combines Project-Based Learning (PjBL) with ethnoscience, specifically centered on science-kit experiments for Elementary School Teacher Education students. The module is systematically designed and its feasibility evaluated through expert validation and field trials, ensuring alignment of content and pedagogy with instructional needs (Anggrella & Sudrajat, 2024). Integrating PjBL and ethnoscience enables Elementary School Teacher Education students to build stronger pedagogical competencies and to connect scientific concepts with learners' local cultural practices. The approach not only emphasizes conceptual understanding but also enhances the relevance and contextualization of learning, enabling Elementary School Teacher Education students to design and implement science instruction that is more participatory, meaningful, and grounded in students' sociocultural experiences. Accordingly, this study aims to develop a module that unites these two approaches, focused on science-kit experiments, to be utilized by Elementary School Teacher Education students in strengthening their pedagogical competence for teaching science, especially in the competence of designing and conducting experiments based on the environment and local wisdom.

## Method

This study utilized the Research and Development (R&D) approach, a method that has been significantly enhanced by the 4D model introduced by Thiagarajan et al. (1974). This model consists of four key stages: Define, Design, Develop, and Disseminate, and offers a unique and systematic framework for the continuous design and evaluation of educational products. It begins with the identification of user needs and culminates in the assessment and dissemination of the finalized product, as depicted in the development phase of the ethnoscience-based Natural Science module in Figure 1.

The Define stage, a comprehensive process, involved in-depth analysis of learner needs. Data were meticulously gathered through structured interviews with fifth-semester students of the Elementary School Teacher Education Study Program at the Faculty of Teacher Training and Education, Universitas Muhammadiyah Makassar, during the 2023/2024 academic year. In addition, extensive consultations were conducted with experts from diverse fields, including science education lecturers and educational practitioners, to gain profound insights into the challenges and requirements of implementing contextual science instruction. Cultural leaders were also engaged to deepen understanding of the philosophies underpinning various forms of local wisdom.

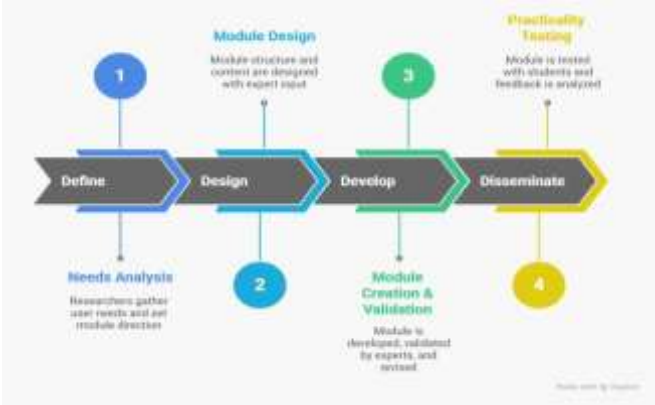


**Figure 1.** 4D implementation in module development

The Design stage was a collaborative effort, involving intensive interaction with experts to ensure the module's relevance, practical applicability, and ease of classroom implementation. The module was structured to support contextual learning anchored in local values. Furthermore, evaluation instruments were developed based on a Project-Based Learning (PjBL) approach, incorporating project tasks and reflective components to assess the extent to which students could integrate theory and practice in the lessons they designed.

**Table 1.** Level of Achievement Based on the Likert Scale

| Achievement Rate (%) | Qualification | Description |
|---|---|---|
| 80-100 | Very good | Very feasible, no need for revision |
| 61-80 | Good | Feasible, no revision needed |
| 41-60 | Good Enough | Not suitable, needs revision |
| 21-40 | Not good | Not feasible, needs revision |
| <20 | Not very good | Very inappropriate, and needs revision |

In the Develop stage, the designed module was meticulously produced and subjected to a rigorous validation process. Development integrated science content with ethnoscience elements and utilized science

kits as practical tools to support classroom experimentation. Validation employed an evaluation rubric addressing didactic and construction aspects for subject-matter experts, as well as textual and visual aspects for media experts, to ensure the module's quality and feasibility. The subject-matter experts' assessment rubric consisted of 15 indicators for didactic requirements and 10 indicators for construction requirements, as detailed in Table 1.

Meanwhile, the media experts' assessment rubric included 10 indicators divided between the quality of text and image elements, as shown in Table 2. Each indicator is rated using a Likert scale and accompanied by a comment section to provide qualitative feedback on aspects of the module that need improvement or enhancement.

**Table 2**. Media Expert Assessment Rubric

| Aspect | Indicator | Item Number | Total Items |
|---|---|---|---|
| Text | Clarity of text (readability), presentation of text, text size and type | 1, 2, 3, 4, and 5 | 5 |
| Images | Image layout, image quality, image attractiveness, relevance of the image to the presented material, and color balance | 6, 7, 8, 9, and 10 | 5 |

The validation results are presented as percentages to determine the product feasibility category, as specified in Table 3. Qualitative feedback from the validators is used to make minor revisions aimed at refining the text, layout, and selection of illustrations and contextual examples to make them more representative.

**Table 3.** Level of Achievement Based on the Likert Scale

| Achievement Rate (%) | Qualification | Description |
|---|---|---|
| 80-100 | Very good | Very feasible, no need for revision |
| 61-80 | Good | Feasible, no revision needed |
| 41-60 | Good Enough | Not suitable, needs revision |
| 21-40 | Not good | Not feasible, needs revision |
| <20 | Not very good | Very inappropriate, and needs revision |

The final stage of the development process is Disseminate, which aims to evaluate the practicality of the module in real learning situations. The module was tested in a limited manner on five Elementary School Teacher Education students in their sixth semester, acting as end users. The students were asked to study the module content, perform the experimental activities, and provide their feedback through a practical evaluation questionnaire. This questionnaire was structured based on the rubric shown in Table 4, which includes 12 assessment items on didactic requirements and 5 items on construction requirements.

**Table 4.** Student Response Grid

| Aspect | Indicator | Item Number | Total Items |
|---|---|---|---|
| Didactic Criteria | Readability of material, images and illustrations, clarity of language, explanation and understanding of material concepts, linkage between physics theory and ethnoscience, application of PjBL, questions and critical thinking, scientific explanation in the context of local culture. | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 | 12 |
| Construction Criteria | Practicality of lab instructions, relevance of the experiment, safety of the experiment, clarity of evaluation, and challenges in practice questions | 13, 14, 15, 16, and 17 | 5 |

The questionnaire uses a Likert scale to measure how easy the students find the module to use, how relevant it is to their learning context, and whether it enhances engagement and understanding of Natural Science concepts. The data are analyzed by calculating the average score and converting it into a percentage based on the criteria in Table 5.

The data obtained in this study were analyzed using a combined approach, namely qualitative descriptive analysis and quantitative analysis based on feasibility percentage. The quantitative data from the validation and practicality evaluation questionnaires were analyzed by calculating the average score for each indicator, which was then converted into percentages to determine the product's feasibility. The scores were compared with categories in Tables 3 and 5 to determine the module's feasibility and practicality status. Meanwhile, the qualitative data, including comments,

notes, and suggestions from validators and students, were analyzed to identify aspects that need improvement or strengthening. The results of this analysis form the basis for making the final revisions to the module. The integration of quantitative and qualitative data provides a comprehensive view of the module's strengths, weaknesses, and potential for further development. After the module had undergone various stages of testing and was deemed practical and appropriate, an effectiveness test was conducted on elementary school teacher education students to assess the impact of the module.

**Table 5**. Practicality Interpretation Criteria

| Achievement Rate (%) | Interpretation Criteria | Description |
|---|---|---|
| 80-100 | Very Practical | Can be used without revision |
| 61-80 | Practical | Usable with minor revisions |
| 41-60 | Practical Enough | Not recommended for use |
| 21-40 | Not Practical | Unusable |
| 0-20 | Not very Practical | Unusable |

## Results and Discussion

The initial analysis was based on structured interviews with 17 students from the Elementary School Teacher Education Study Program in the Faculty of Teacher Training and Education, Universitas Muhammadiyah Makassar, who had completed a science learning session incorporating Project-Based Learning (PjBL) and ethnoscience principles. The interview aimed to elicit students' insights into their conceptual understanding of science, the pedagogical effectiveness of the methods used, and the significance of local cultural elements. Student responses were collected in the form of percentages based on five response categories: strongly disagree, disagree, neutral, agree, and strongly agree. The results of the initial analysis can be seen in Table 6.

**Table 6**. Results of Questionnaire Analysis in Needs Identification

| Interview questions | Interview results (%) | | | | |
|---|---|---|---|---|---|
| | SD | D | N | A | SA |
| How easy is it for you to understand the IPA concepts taught in class? | 0 | 0 | 23.53 | 47.06 | 29.41 |
| How important do you think practical activities are in deepening your understanding of IPA concepts? | 0 | 0 | | 17.65 | 82.35 |
| To what extent do you feel that Project-Based Learning (PBL) can help your understanding of IPA material? | 0 | 0 | 0 | 29.41 | 70.59 |
| How interested are you in working on projects that integrate scientific knowledge with local wisdom or traditional culture? | 0 | 0 | 0 | 0 | 100.00 |
| How useful do you find the teaching materials (which include images, videos, practical activities, and exercises) in the IPA learning process? | 0 | 0 | 0 | 23.53 | 76.47 |
| Do you feel the need for an IPA learning module/book that integrates local wisdom (ethnoscience) with the Project-Based Learning approach? | 0 | 0 | 0 | 0 | 100.00 |

The interview results show that most students felt capable of understanding the Natural Science concepts taught. A total of 47.06% reported that they found the science concepts taught to be easy to understand, 29.41% found them very easy, and 23.53% were neutral, indicating that most students were able to master the content. In addition, almost all respondents (82.35%) considered laboratory practicum activities essential for deepening conceptual understanding, while the remaining 17.65% regarded them as necessary. Regarding the implementation of Project-Based Learning (PjBL), 70.59% stated that PjBL greatly helped them understand science content, whereas 29.41% considered it helpful, suggesting strong confidence in the method's effectiveness. Furthermore, 76.47% felt that instructional materials incorporating images, videos, practicum activities, and exercises were very useful in the science learning process, while 23.53% considered them valuable. Finally, 100% expressed a strong interest in undertaking projects that integrate scientific knowledge with local wisdom and agreed on the need for a science learning module that integrates ethnoscience with the PjBL approach.

Based on the needs analysis and existing findings, there is a clear imperative to develop a PjBL-based science learning module that integrates ethnoscience to optimize learning outcomes and align content with students' local contexts. Accordingly, at the Design stage, module development commenced with Learning Objectives formulated across two primary domains: (1) knowledge, encompassing mastery of key concepts and their connections to local practices; and (2) skills,

covering the execution of procedures, data analysis, and evidence-based reporting. These objectives serve as the foundation for constructive alignment, ensuring that all module components mutually reinforce one another. Contextual relevance is strengthened through a Story with Local Wisdom that links local values and traditions as an advanced organizer. Implementation readiness is ensured through an Experimental Preparation List that details apparatus, materials, specifications, low-cost alternatives, and logistical notes, in conjunction with a Risk Identification and Control document that specifies PPE requirements, do-and-don't checklists, safe workspace arrangements, and emergency procedures. The core content is then merged into Integrated Local Wisdom Material, built around case studies of local wisdom to ensure meaningfulness while creating space for innovation through systematic comparisons between local practices and scientific principles.

To guarantee effective enactment, Learning Instructions are articulated clearly and sequentially. Experimental Steps outline the workflow, outcome criteria, troubleshooting guidance, and safety warnings, which are placed precisely at points of risk, including waste-disposal procedures and end-of-activity clean-up. Design coherence is finalized through Evaluation Questions comprising multiple-choice items to assess conceptual understanding, cause-and-effect reasoning, data interpretation, and contextual transfer, with distractors reflecting locally prevalent misconceptions. Essay prompts are also included to evaluate evidence-based argumentation, integration of local wisdom, and ethical and safety considerations.


**Figure 2.** Structure of the PjBL-based ethnoscience module in science education

Visually enhanced with a culturally themed, engaging cover, this module facilitates students' understanding of heat transfer through hands-on experiments and guided calculations. It also links scientific principles to real-world community practices. The instructional components support students in planning contextually relevant experiments, enhancing analytical capabilities, and producing well-structured reports. The overarching goal is for students to investigate, validate, and contextualize scientific principles within ethnoscientific settings.

In the Development stage, Prototype I incorporated structural elements including a Course Learning Outcomes map, concept mapping, core content, contextual Project-Based Learning (PjBL) activities, and task rubrics. Ethnoscience was embedded by aligning heat and temperature concepts with traditional palm sugar production in South Sulawesi, supplemented by simplified, locally sourced experiments. The module's front matter, which includes the cover design, instructional guidelines, and learning objectives, is illustrated in Figure 3.


**Figure 3.** Cover design, learning instructions, learning objectives

The core content of this module begins with the story of Kakek Baco (Figure 4), a traditional palm sugar maker in South Sulawesi, linking the sugar-making process to the principles of heat transfer. This story helps students understand the connection between science and local cultural practices, making learning more contextual and applicable. The story at the beginning of the module is characteristic of teaching material development, covering heat energy, heat transfer, and temperature changes in a scientific explanation that incorporates relevant formulas and theories. Students will design experiments to test these scientific principles and perform in-depth calculations to support their findings.

Furthermore, the experimental procedures are planned with explicit attention to risk identification, preparation of tools, materials, and safety procedures. This module not only teaches scientific concepts but also invites students to explore how science is applied in everyday life, particularly within their local culture. By combining theory and practice, this module aims to enrich students' knowledge and skills in science while fostering an appreciation for local cultural values.

**Figure 4.** Example of content design

During the development phase, a feasibility evaluation was undertaken, in which the module was validated by three experts: two subject-matter specialists and one media/design specialist, using a five-point Likert scale (1–5). The evaluation aimed to ensure that the designed module met academic, pedagogical, and visual criteria, thereby making it ready for implementation in the Elementary School Teacher Education program. The review covered two principal dimensions: (i) the feasibility of content and structure in terms of didactic soundness and construction, and (ii) the feasibility of the design with respect to media presentation and the visual elements employed.

*Subject Matter Expert Assessment*

The results from the assessment by two subject matter experts showed that the module received very high scores in two main categories: didactic requirements and construction requirements. In the didactic category, the average score was 94.00%, with scores of 93.33% and 94.67% from each expert. This indicates that the module was developed with attention to relevant learning principles that suit student characteristics and target specific learning outcomes. Specifically, the module was assessed as meeting content alignment with the curriculum, the meaningfulness of learning, and a constructivist approach. Additionally, the ethnoscience approach used in the module was assessed as successfully linking Natural Science concepts with local realities, increasing the relevance and context of the material taught.

In the construction requirements category, the evaluation also showed a very high level of feasibility. The module received an average score of 96.00%, with expert scores of 98.00% and 94.00%. This reflects that the module was designed with a systematic, logical structure that is easy to understand. The evaluation of the module's construction included aspects such as coherence between sections, consistency in terminology and language, and the integration of goals, content, activities, and assessments. Validators assessed that the module effectively guides students through the learning process, from problem exploration and solution design to conducting locally based experiments and producing project outcomes. The module was also considered flexible and adaptable for use in various learning conditions, both individually and collaboratively, in face-to-face and online settings. The expert evaluation results are shown in Table 7.

**Table 7.** Expert Evaluation Results on the Ethnoscience-Based PBL Module

| Indicator | Validator 1 | Validator 2 | Average (%) | Description |
|---|---|---|---|---|
| Didactic Criteria | 93.33 | 94.67 | 94.00 | Very Feasible |
| Construction Criteria | 98.00 | 94.00 | 96.00 | Very Feasible |

The learning module, which has been evaluated by validators, was then adjusted based on their feedback and comments. Although the module was generally rated as highly feasible, there were still areas for quality improvement, as shown in Table 8.

**Table 8.** Revision Results of the Ethnoscience Learning Module Validation

| Validator suggestions and comments | Before Revision | After Revision |
|---|---|---|
| Add emphasis on the title related to the words "ethnoscience" and "temperature." |  |  |
| Expand the canvas of the image in the story section |  |  |
| Add equations to the material |  |  |

The comprehensive evaluations provided by the experts offer strong validation of the module's quality, both in terms of substance and media design. These assessments indicate that the module meets the academic feasibility criteria as a teaching tool in the field of Natural Science, while also fulfilling aesthetic and technical standards as an engaging and accessible learning medium. Overall, the feedback from the validators highlights that this module has great potential in supporting the improvement of Natural Science learning quality at the elementary education level, particularly through the delivery of contextual, applicable, and culturally-based content.

*Media Expert Assessment*

The results from the media expert evaluation show that the module received maximum scores on most indicators, indicating excellent quality. The cover design received a score of 100%, reflecting a professional and attractive appearance that effectively represents the essence of the module through typography, visual composition, and illustrations that align with the theme of culture-based Natural Science. The typography and readability were also flawless, with appropriate font choices, sizes, spacing, and text placement that facilitated comprehension of the material. The integration of content received a score of 100%, indicating that visual elements and text complement each other to reinforce scientific concepts. The use of images and graphics was functional, helping bridge abstract concepts with concrete local contexts, making the learning experience more meaningful. The quality and layout of images supported the flow of students' thinking, reduced cognitive load, and clarified the relationship between text and illustrations.

The color usage also received a perfect score. The color scheme was consistent, harmonious, and easy to read, functioning as a visual marker for navigation and content segmentation. The colors, inspired by local culture, strengthened the connection between the material and the students' cultural context. The only indicator that did not score perfectly was the relevance and function of elements, with a score of 90%. The media expert evaluation results are shown in Table 9.

**Table 9.** Results of Media Expert Evaluation of the Design Aspects of the Ethnoscience-Based PjBL Module

| Indicator | Criteria (%) | Description |
|---|---|---|
| Cover Design | 100 | Very Feasible |
| Typography and Readability | 100 | Very Feasible |
| Content Cohesion | 100 | Very Feasible |
| Image Quality and Layout | 100 | Very Feasible |
| Use of Color | 100 | Very Feasible |
| Element Relevance and Function | 90 | Very Feasible |
| Average | 98.33 | Very Feasible |

These media evaluation results reinforce the findings from the previous phases, demonstrating that the module is not only substantively and pedagogically strong but also excels in terms of visual appeal and supporting media. An average score of 98.33% indicates a very high level of feasibility, suggesting that this module is well prepared for use in real learning contexts. The balance between content and media aspects makes this module a holistic learning tool, where students not only gain cognitive understanding of Natural Science concepts but also enjoy an engaging, enjoyable, and culturally meaningful learning experience.

*One-to-one Evaluation Results*

At this stage, students were provided with Prototype I of the ethnoscience-based PjBL module. Each student was asked to read, study, and carry out every procedure in the module while receiving guidance and instructions from the researchers. Subsequently, students completed a questionnaire eliciting their responses to the Prototype I they had used. The results of the student response evaluation are presented in Table 10.

**Table 10.** Results of Student Evaluation of the Ethnoscience-Based PjBL Module

| Indicator | Average (%) | Description |
|---|---|---|
| Didactic Criteria | 93.33 | Very Feasible |
| Construction Criteria | 93.60 | Very Feasible |

The implementation evaluation indicates that the module falls within the "very feasible" category on two primary criteria: didactic (93.33%) and construction (93.60%). The didactic score evidences strong alignment between learning objectives and the learning experiences facilitated by the module, fostering meaningful learning through active individual and collaborative engagement and encouraging reflection. The construction score confirms a coherent and logically sequenced design, where activities progress from orientation and exploration to information processing and the presentation of project outputs, supported by clear technical guidance and close alignment among objectives, project tasks, and assessment instruments. Collectively, these findings suggest that the module is ready for broader implementation on the topic of temperature, heat its changes, with minor enhancements in formative feedback and the differentiation of learning resources, which are likely to optimize learning outcomes further.

*Small-Group Evaluation Results*

Following confirmation of validity and practicality in the preceding stage, Prototype II underwent a small-group evaluation. This phase resembled the one-to-one

evaluation but differed in that the ethnoscience-based project-based learning (PjBL) module (Prototype II) was piloted with five students from the Elementary School Teacher Education program at Universitas Muhammadiyah Makassar. The students were asked to read, analyze, discuss, and practice each instruction contained in the Prototype II module. Student learning outcomes are reported in Table 10.

**Table 11.** Recapitulation of the Results of the Small Group Stage Learner Questionnaire

| Learner Name | Percentage (%) |
|---|---|
| SRA | 90.50 |
| NIB | 94.50 |
| RA | 91.50 |
| HSR | 92.50 |
| MWL | 91.00 |
| Average | 92.00 |
| Category | Very Practical |

Based on Table 11, the small-group evaluation yielded a mean learner rating of 92.00%, placing the module in the "very practical" category. Individual scores ranged from 90.50% to 94.50%, with the highest score achieved by NIB (94.50%) and the lowest by SRA (90.50%). The narrow dispersion (range = 4.00 percentage points; SD ≈ 1.58) indicates convergent perceptions among participants, reflecting clarity of instructions, coherent sequencing of activities, and ease of implementation. Collectively, these findings substantiate the practicality of Prototype II of the ethnoscience-based PjBL module on temperature, heat, and their changes, and indicate readiness for broader deployment.

*Field Test Results*

During the Field Test phase, implementation was carried out in a single sample class comprising 37 students from the Elementary School Teacher Education Study Program, Faculty of Teacher Training and Education, Universitas Muhammadiyah Makassar. To examine learning gains associated with use of the module, a pre-experimental approach was employed. Students completed a pretest and posttest, each consisting of 10 items aligned with indicators designed to measure experimental competencies and the ability to connect concepts to real-life contexts. The results of the normalized gain (N-gain) analysis are presented in Table 12.

**Table 12.** Percentage Increase in N-gain Student's Results

| | N | Pre test | Post test | N-Gain Score | N-Gain score percent |
|---|---|---|---|---|---|
| Average | 37 | 74 | 95 | 0.80 | 80 |
| Category | | | | High | Affective |

The mean pretest score of 74 increased to 95 on the posttest, representing an absolute gain of 21 points (≈ 28.4% relative to the baseline). The average normalized gain (N-Gain) was 0.80, classified as high, indicating that students achieved approximately 80% of the maximum attainable improvement. Pedagogically, this growth pattern aligns with the module's design, which scaffolds learners through problem identification, hypothesis formulation, specification of variables and procedures, data collection and analysis, and the drawing of conclusions and reflection, while explicitly encouraging them to relate experimental outcomes to contextual phenomena (e.g., temperature changes in everyday activities). The alignment among learning objectives, project-based activities, and performance assessments fostered sustained cognitive engagement and meaningful inquiry, thereby systematically strengthening competencies in experimental design and in making real-world connections. These findings indicate that the module meets the effectiveness criterion and is ready for broader use in coursework.

*Discussion*

This study presented strong empirical evidence that confirmed the pedagogical, practical, and instructional merit of an ethnoscience-integrated Project-Based Learning (PjBL) module designed for elementary teacher education. The validation process consistently yielded high ratings across the didactic (94.00%), structural (96.00%), and visual design (98.33%) dimensions, demonstrating the module's structural coherence, content alignment, and aesthetic clarity. These outcomes reinforced the existing literature, which indicated that integrating ethnoscientific content within instructional frameworks significantly enhanced conceptual accessibility and contextual relevance for learners (Yuliyanti et al., 2024; Wardani et al., 2024). By embedding local cultural practices within scientific learning, the module strengthened pedagogical foundations and facilitated meaningful learning experiences that align with the realities of pre-service teachers and their future classrooms (Sihombing et al, 2025; Listia et al., 2025).

The integration of local wisdom, specifically the traditional process of palm sugar production, as a contextual anchor for understanding thermodynamic

concepts, exemplified how abstract scientific ideas were localized and made tangible. This approach encouraged learners to engage not only in empirical inquiry but also in epistemological reflection, thereby fostering deeper cognitive engagement and cultural awareness (Curran et al., 2015; Fatimah, 2023; Idul & Fajardo, 2023). These findings supported prior assertions that ethnoscience-based instruction enabled learners to evaluate and apply scientific principles to real-life contexts critically, thereby enrichined their scientific understanding while respecting indigenous knowledge systems (Agustia et al., 2024; Putri et al., 2024). The ethnoscience-PjBL synergy presented in the module, therefore, acted as a transformative pedagogical platform that bridged science with sociocultural identity.

The module's implementation through PjBL further strengthened its impact by guiding students through structured phases of exploration, problem identification, experimentation, and reflection, an approach that enhanced higher order thinking skills, particularly critical and creative thinking (Loyens et al., 2023; Khafah et al., 2023; Sungkono & Ekaputra, 2023; Sucilestari et al., 2023). These results aligned with research emphasizing that PjBL fostered learner autonomy, innovation, and collaborative engagement, particularly when rooted in authentic and culturally responsive contexts (Poonputta & Sakorn, 2025; Anggraeni et al., 2023). Students became active constructors of knowledge, engaging with content both scientifically and in a contextual manner. The learning scenarios presented in the module required interdisciplinary synthesis and reflective analysis, encouraging the development of pedagogical adaptability and instructional creativity among pre-service teachers.

The module's practical utility was further validated through user response scores, with a mean practicality rating of 92.00%, demonstrating its usability, clarity, and relevance. These findings were consistent with previous studies, which confirmed the practical benefits of well-designed, ethnoscience-integrated instructional tools in teacher education (Melinia et al., 2024; Nurussalamah et al., 2025). The observed gains in learning outcomes, evidenced by an N-Gain score of 0.80, underscored the module's effectiveness, aligning with the results reported by Chamdani et al. (2025) and Pieter et al. (2025), who observed significant improvements in science literacy and process skills following the use of ethnoscientific project-based modules. Collectively, these findings supported the theoretical stance that science learning grounded in culturally familiar frameworks enhanceed not only content mastery but also learner engagement, motivation, and instructional performance (Hikmawati et al., 2022; Rahayu et al., 2023).

This study has several limitations. The implementation was restricted to a single institution and addressed only one science topic, which might have affected the generalizability of the findings. Additionally, employing a pre-experimental design without a control group weakened the ability to draw strong causal inferences. Future research should employ quasi-experimental or longitudinal designs and integrate multidimensional assessments such as performance-based tasks and classroom observations to provide a more comprehensive evaluation of the intervention's effectiveness (Pratami et al., 2024; Cham et al., 2024).

## Conclusion

This research validated that the integration of ethnoscience with Project-Based Learning (PjBL) offers a valid, practical, and effective pedagogical strategy for enhancing science education within elementary teacher training. The developed module, which contextualized abstract scientific concepts through culturally grounded experimentation (e.g., traditional palm sugar processing), received high feasibility ratings from expert validators (didactic: 94.00%, construction: 96.00%, visual: 98.33%) and positive user feedback (practicality: 92.00%). Its effectiveness was further confirmed by a high normalized gain (N-Gain = 0.80), indicating substantial improvement in students' conceptual understanding, critical thinking, and ability to connect science with everyday cultural practices. These results validated the module's capacity to foster meaningful, reflective, and locally relevant science learning experiences. Beyond practical outcomes, this research contributed to the theoretical and methodological advancement of culturally responsive science pedagogy. By embedding ethnoscientific principles within an experiential PjBL framework, the study provided a replicable model that addressed curriculum demands for contextualization, relevance, and 21st-century skill development. While the study was limited to a single topic and institutional setting, its findings underscored the transformative potential of localized instructional design in Elementary School Teacher Education.

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All authors contributed to the development of the module, writing and revising the article. The duties of each author. Conceptualization; N, M. A. S, A. A, A. A. M, Methodology; N,

A. A, Validation and Formal analysis, data curation; N, M. A. S, A. A, data collection by conducting the study; N, M. A. S, A. A, A. A. M, design and visualization; A. A. M, writing, review and editing; S, M. A. S. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest**
The authors declare no conflict of interest that could affect the objectivity, integrity, or results of this research.

## References

Agustia, M., Murni, P., & Ernawati, M. D. W. (2024). Development of ethnoscience-based pbl-networked learning tools to improve students' understanding of entrepreneurship concepts and interests. *Edu Sains Jurnal Pendidikan Sains & Matematika*, *12*(1), 99–109. https://doi.org/10.23971/eds.v12i1.6109

Akmal, A. U. (2021). Analisis Etnosains Dalam Pembelajaran IPA di SekolahDasar (SD) Kota Padang Dan Bukittinggi. *Jurnal Inovasi Pendidikan Dan Pembelajaran Sekolah Dasar*, *4*(2), 68. https://doi.org/10.24036/jippsd.v4i2.111385

Amran, M., & Muslimin, M. (2017). Peningkatan Hasil Belajar dengan Menggunakan Media KIT IPA di SD Negeri Mapala Makassar. *Jurnal Office*, *3*(1), 66. https://doi.org/10.26858/jo.v3i1.3465

Anattri, L., Yelianti, U., & Subagyo, A. (2024). Development of an Ethnoscience-Based Teaching Module on Incung Kerinci Batik as a Learning Resource for Biology of Plant Material (Plantae). *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6215–6229. https://doi.org/10.29303/jppipa.v10i8.7664

Andriyanto, A., & Rahdiyanta, D. (2025). Systematic Literature Review the Influence of Project-Based Learning (PJBL) on Critical Thinking and Creative Thinking Skills of Vocational High School Students. *International Journal of Research and Innovation in Social Science*, *VIII*(XII), 977–982. https://doi.org/10.47772/IJRISS.2024.8120082

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*, 101334. https://doi.org/10.1016/j.tsc.2023.101334

Anggrella, D. P., & Sudrajat, A. K. (2024). Development of an Integrated Project-Based Learning Module Based on Black Soybean Ethnoscience to Improve Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3038–3045. https://doi.org/10.29303/jppipa.v10i6.5855

Cham, H., Lee, H., & Migunov, I. (2024). Quasi-experimental designs for causal inference: an overview. *Asia Pacific Education Review*, *25*(3), 611–627. https://doi.org/10.1007/s12564-024-09981-2

Chamdani, M., Suryandari, K. C., & Wijayanti, M. D. (2025). The Project Based Learning Integrated Ethnoscience: A Model of Learning to Enhance Scientific Literacy Among Pre-Service Elementary Teacher. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 1195–1202. https://doi.org/10.29303/jppipa.v11i4.9679

Curran, T., Hill, A. P., Appleton, P. R., Vallerand, R. J., & Standage, M. (2015). The psychology of passion: A meta-analytical review of a decade of research on intrapersonal outcomes. *Motivation and Emotion*, *39*(5), 631–655. https://doi.org/10.1007/s11031-015-9503-0

Fatimah, S. (2023). How Does Local Wisdom in Science Learning? Research Trend Analysis Through Bibliometric in 2018-2023. *Social, Humanities, and Educational Studies (SHES): Conference Series*, *6*(3), 189–200. https://doi.org/10.20961/shes.v6i3.82323

Hartini, S., Firdausi, S., Misbah, & Sulaeman, N. F. (2018). The development of physics teaching materials based on local wisdom to train Saraba Kawa characters. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 130–137. https://doi.org/10.15294/jpii.v7i2.14249

Hikmawati, H., Sutrio, Wahyudi, & Syahidi, K. (2022). Effects of Learning with Ethnoscience Context on Learning Outcomes in Cognitive Aspects of Prospective Physics Teacher Students. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2793–2801. https://doi.org/10.29303/jppipa.v8i6.2388

Holmes, K., Mackenzie, E., Berger, N., & Walker, M. (2021). Linking K-12 STEM Pedagogy to Local Contexts: A Scoping Review of Benefits and Limitations. *Frontiers in Education*, *6*, 693808. https://doi.org/10.3389/feduc.2021.693808

Idul, J. J. A., & Fajardo, M. T. M. (2023). Ethnoscience-based physical science learning and its effects on students' critical thinking skills: A meta-analysis study. *Journal of Mathematics and Science Teacher*, *3*(2), em048. https://doi.org/10.29333/mathsciteacher/13700

Indayani, L. (2015). Peningkatan prestasi belajar peserta didik melalui penggunaan media KIT IPA di SMP Negeri 10 Probolinggo. *Jurnal Kebijakan Dan Pengembangan Pendidikan*, *3*(1), 54–60. https://doi.org/10.22219/jkpp.v3i1.2197

Ismail, N. (2016). Pemanfaatan Media Kit Oleh Guru Dalam Pembelajaran IPA Untuk Meningkatkan Hasil Belajar Siswa di SMP Negeri 4 Kota

Singkawang. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *1*(1), 16. https://doi.org/10.26737/jipf.v1i1.55

Juita, D., & Irawani, F. (2025). Collaboration skills of Phase F high school students through physics electronic modules based on project-based learning integrated with local wisdom Maelo Pukek. *Jurnal Penelitian Pendidikan IPA*, *11*(8). https://doi.org/10.29303/jppipa.v11i8.11082

Khafah, F., Suprapto, P. K., & Nuryadin, E. (2023). The effect of project-based learning model on students' critical and creative thinking skills in the ecosystem concept. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(3), 244–255. https://doi.org/10.22219/jpbi.v9i3.27461

Latip, A., Hernani, & Kadarohman, A. (2024). Local and indigenous knowledge (LIK) in science learning: A systematic literature review. *Journal of Turkish Science Education*, *21*(4), 651–667. https://doi.org/10.36681/tused.2024.035

Listia, A. P., Wijayanti, A., Ernawati, T., & Septiani, D. (2025). Integration of Local Culture in the Search, Solve, Create and Share (SSCS) Learning Model to Improve Scientific Literacy: A Literature Review. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *15*(1), 357–374. https://doi.org/10.30998/formatif.v15i1.27945

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

Melinia, S., Ismet, & Yusup, M. (2024). Development of Physics Module Based on Ethnoscience with the Local Wisdom of House Limas Palembang to Improve Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8319–8327. https://doi.org/10.29303/jppipa.v10i11.8654

Morgado, S., Leite, L., & Dourado, L. (2022). Teaching for the contextualized learning of science: A checklist-based science curriculum analysis. *Journal of Turkish Science Education*, *19*(4), 1072–1095. https://doi.org/10.36681/tused.2022.163

Mukti, H., Suastra, I. W., & Aryana, I. B. P. (2025). Integrasi etnosains dalam pembelajaran IPA. *JPGI (Jurnal Penelitian Guru Indonesia)*, *7*(4), 356–362. https://doi.org/10.29210/022525jpgi0005

Nasharuddin, Hajra Yansa, & Miftahul Janna. (2024). Pengaruh Penggunaan KIT IPA terhadap Keterampilan Literasi dan Proses Sains Mahasiswa Pendidikan Guru Sekolah Dasar. *Jurnal Pendidikan MIPA*, *14*(2), 447–454. https://doi.org/10.37630/jpm.v14i2.1561

Nollmeyer, G. E., & Baldwin, K. A. (2024). Strengthening Elementary Preservice Teacher Content Knowledge in Science through Model Based Inquiry. *Creative Education*, *15*(10), 2131–2150. https://doi.org/10.4236/ce.2024.1510131

Nurussalamah, U., Fatmaryanti, S. D., & Sriyono. (2025). Integrating E-Module with Project Based Learning (PjBL): a Strategy to Improve Students' Collaboration Abilities and Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 936–945. https://doi.org/10.29303/jppipa.v11i3.10864

Pieter, J., & Risamasu, P. V. M. (2024). Integrating Ethnoscience in Physics Teaching Materials and its Impact on Student's Science Process Skills and Mastery Concept. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 2948–2955. https://doi.org/10.29303/jppipa.v10i6.7210

Poonputta, A., & Sakorn, W. (2025). Developing Pre-service Teachers' Mathematics Teaching Skills and Attitude through Project-Based Learning and Reflective Learning. *Educational Process International Journal*, *16*(1), 2025216. https://doi.org/10.22521/edupij.2025.16.216

Pratami, D., Hasrul Akhmal, N., Isyraf Mohd Maulana, M. I., & Helmi Syed Hassan, S. A. (2024). Introducing project-based learning steps to the preschool teachers in Bandung, Indonesia. *Journal of Technology and Science Education*, *14*(3), 883. https://doi.org/10.3926/jotse.2398

Putri, R. S. S., Jasruddin, J., & Mustafa, M. (2024). The Relationship between Ethnoscience and Creative Thinking Skills to Support 21st Century Learning for High School Student in West Sulawesi: Literature Review. *International Journal of Current Science Research and Review*, *07*(11). https://doi.org/10.47191/ijcsrr/v7-i11-31

Rahayu, R., Sutikno, & Indriyanti, D. R. (2023). Ethnosains Based Project Based Learning Model with Flipped Classroom on Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 348–355. https://doi.org/10.29303/jppipa.v9i8.3051

Rediani, N. N., Kaize, B. R., Hanifah, S., Nainggolan, H. T., Dharma Sanjaya, P. M., & Hallatu, T. G. . (2023). Developing Environmental Care Attitudes and Scientific Literacy through Sasi Local Wisdom-Based E-Modules. *Jurnal Pedagogi Dan Pembelajaran*, *6*(2), 238–246. https://doi.org/10.23887/jp2.v6i2.64518

Sihombing, R. A., Anwar, S., Liu, S.-Y., Muslim, M., Winarno, N., & Sihombing, P. J. (2025). Integrating Local Wisdom into Environmental Education: A Systematic Review of Ethnoscience Research in Indonesia. *Journal of Natural Science and Integration*, *8*(1), 57. https://doi.org/10.24014/jnsi.v8i1.35762

Suciati. (2023). Integrating local wisdom in science learning: An opportunities and challenges. In A.

Doyan (Ed.), *1st International Conference on Science Education and Sciences (AIP Conference Proceedings: Vols. 2619), Art* (p. 100018). https://doi.org/10.1063/5.0125371

Sucilestari, R., Ramdani, A., Sukarso, A., Susilawati, S., & Rokhmat, J. (2023). Project-Based Learning Supports Students' Creative Thinking in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1038–1044. https://doi.org/10.29303/jppipa.v9i11.5054

Sudarmin, S., Handayani, L., Sarwi, S., Hardianti, R. D., Eralita, N., Sumarni, W., & Hutagalung, F. D. (2024). Development of Innovative Ethno-Vlog Media Based on Ethno-STEM to Equip Students' Creativity and Realize UNNES Conservation Vision. *Journal of Innovation in Educational and Cultural Research*, *5*(3), 529–539. https://doi.org/10.46843/jiecr.v5i3.1749

Sudarmin, S., Zahro, L., Pujiastuti, S. E., Asyhar, R., Zaenuri, Z., & Rosita, A. (2019). The Development of PBL-Based Worksheets Integrated with Green Chemistry and Ethnoscience to Improve Students' Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 492–499. https://doi.org/10.15294/jpii.v8i4.17546

Sungkono, S., & Ekaputra, F. (2023). Effectiveness of project-based learning model on improving critical thinking skills and student creativity. *Daengku: Journal of Humanities and Social Sciences Innovation*, *3*(5), 859–863. https://doi.org/10.35877/454RI.daengku2063

Thiagarajan, S. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. Bloomington: Indiana University.

Thompson, S. L., Fan, X., & Adgerson, A. J. (2024). Exploring a practice-based approach to elementary preservice science teacher preparation. *School Science and Mathematics*, 1–14. https://doi.org/10.1111/ssm.12663

Vrbová, P. (2022). The effectiveness of project-based learning in developing critical thinking skills. *Journal of Informatics Education and Research*, *2*(2). https://doi.org/10.52783/jier.v2i2.17

Wardani, R. P., Nuriman, N., Wardoyo, A. A., Agustiningsih, A., & Mahmudi, K. (2024). Etnosains dalam Pembelajaran IPA SD di Budaya Banyuwangi. *Jurnal Ilmu Pendidikan Sekolah Dasar*, *11*(3), 248. https://doi.org/10.19184/jipsd.v11i3.52818

Widiana, I. W., Tegeh, I. M., Lanang Agung Parwata, I. G., & . H. . (2020). Improving Student's Factual Knowledge with Concrete Media through Observing Activities in Scientific Approaches in Elementary Schools. *Journal of Education and E-Learning Research*, *7*(3), 293–299. https://doi.org/10.20448/journal.509.2020.73.293.299

Yuliyanti, N., Sarwi, S., Wardani, S., & Fathonah, S. (2024). Integration of social science learning through a child-friendly ethnoscience approach. *Proceedings of International Conference on Science, Education, and Technology*, *10*(1), 250–258. Retrieved from https://proceeding.unnes.ac.id/ISET/article/view/3886

Yusa, D., Diani, N., & Setiawan, M. (2023). Penerapan pembelajaran berbasis masalah dalam pendidikan IPA di PGSD. *Jurnal Pembelajaran Dan Pendidikan*, *8*(2), 188–203. https://doi.org/10.1016/j.jpd.2023.1235

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. *Frontiers in Psychology*, *14*, 1202728. https://doi.org/10.3389/fpsyg.2023.1202728

Zidny, R., Sjöström, J., & Eilks, I. (2020). A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability. *Science & Education*, *29*(1), 145–185. https://doi.org/10.1007/s11191-019-00100-x