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DEVELOPMENT OF ETHNO-STEM TEACHING MATERIALS TO ENHANCE APPRECIATION OF LOCAL WISDOM AND CREATIVITY IN UNIVERSITY STUDENTS: A CASE STUDY IN LAMONGAN

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ABSTRACT

The challenges of 21st-century education demand university graduates who are not only academically competent but also creative and rooted in their national culture. This study aims to produce valid and practical Ethnoscience-based STEM (Ethno-STEM) teaching materials, test the effectiveness of the teaching materials in enhancing appreciation of local wisdom, and test their effectiveness in increasing student creativity. The research method utilized is Research and Development (R&D) using the 4-D model (Define, Design, Develop, Disseminate). The subjects for the field trial (Develop stage) were 25 Science Education students from Universitas Islam Lamongan selected via purposive sampling based on enrollment in relevant courses, while the Disseminate stage involved 30 students from the faculty scope. Data collection instruments included expert validation sheets, student response questionnaires, local wisdom appreciation questionnaires, and creativity tests. Validation results by 6 experts showed the teaching materials were highly feasible with an average percentage of 88.95%. Practicality tests showed a very practical category (88.33%), and user responses at the dissemination stage reached 87.50% (very good). Effectiveness tests showed an increase in creativity in the medium category (N-Gain 0.52) and an increase in local wisdom appreciation in the high category (N-Gain 0.71). It is concluded that the developed Ethno-STEM teaching materials are valid, practical, and effective for implementation in lectures.

Keywords: Ethno-STEM; local wisdom; creativity; science education; higher education

INTRODUCTION

Improving the quality of human resources is a primary priority in preparation for *Indonesia Emas 2045* (Golden Indonesia 2045). Current education policies emphasize the importance of an adaptive curriculum to equip students with future skills. As stated by Suharjo & Jacky (2023), the integration of the *Merdeka Belajar Kampus Merdeka* (MBKM) policy is a strategic key in preparing competent graduates. In higher education, the Science, Technology, Engineering, and Mathematics (STEM) approach is crucial for equipping students with 21st-century skills, particularly creativity. Tabassum *et al*., (2024) assert that STEM education has a significant impact on the development of creativity in university students. However, Western-centric STEM implementation often overlooks students' cultural backgrounds, creating a gap between scientific concepts and social reality. Adam *et al*., (2025) emphasize the need for a bridge between culture and science through a culturally relevant approach to address this gap.

Recent bibliometric analysis of global literature shows a significant increasing trend in the integration of STEM education with local wisdom (ethnoscience) to support sustainability (Rosyidah *et al*., 2025; Yuliana *et al*., 2025). Indonesia is recorded as a major contributor to this research, yet the majority of studies are still focused on the secondary school level. Dewi *et al*., (2025) in their systematic review, highlight that local wisdom-based socioscientific issues are highly potential but have not been maximally explored at the higher education level. Specific studies regarding Ethno-STEM in the context of culturally responsive higher education remain a rarely explored theme (Budiman & Suwarma, 2025). In fact, integrating local knowledge into the higher education curriculum is a strategic imperative to create a relevant and transformative education system (Ramli *et al*., 2025). Kartika *et al*., (2025) add that students' critical thinking profiles can develop optimally if supported by an appropriate Ethno-STEM learning model.

Based on a preliminary needs analysis in the Science Education Study Program at Universitas Islam Lamongan, the main obstacle found was the absence of structured teaching materials integrating ethnoscience into STEM lectures. Lecturers experienced difficulty finding references that combine scientific content with local cultural contexts, as well as a lack of adequate project activity guides (worksheets). Santoso *et al*., (2024) revealed that students require innovative teaching materials capable of facilitating active learning. This has resulted in the suboptimal development of students' creativity and cultural appreciation. Santoso *et al*., (2025) highlighted that lecturer-centered learning remains a major obstacle to creativity development, necessitating the intervention of innovative teaching materials.

Previous research has proven the effectiveness of the Ethno-STEM approach at various levels. Hikmah *et al*., (2025) revealed the great potential of ethnoscience in improving science literacy. At the school level, Anggreini *et al*., (2024) and Pada *et al*., (2025) successfully improved students' thinking skills and environmental awareness through Ethno-STEM-based inquiry. On the other hand, Sumarni *et al*., (2022) emphasized the importance of blended inquiry for chemical literacy. Harjono *et al*., (2025) found that an ethnoscience-based inquiry model improved higher-order thinking skills. Similarly, Sumarni *et al*., (2025) reported increased collaboration and creativity in pre-service science teachers through ethnoscience-infused project-based learning.

Theoretically, the integration of Ethnoscience into STEM provides a scaffolding bridge that connects abstract scientific concepts with students' familiar cultural knowledge (Sudarmin *et al*., 2025; Sumarni *et al*., 2022). This contextualization reduces extraneous cognitive load, allowing students to allocate more cognitive resources to higher-order thinking processes, such as creativity. When students explore STEM problems rooted in their local wisdom, they engage in fluent and flexible thinking key components of creativity because they understand the context deeply. Empirically, previous studies have shown that culturally relevant pedagogy not only improves conceptual understanding but also triggers creative problem-solving by encouraging students to reconstruct

indigenous knowledge into scientific explanations (Sudarmin *et al*., 2025; Tabassum *et al*., 2024). This study aims to fill this gap by developing Ethno-STEM teaching materials that are valid, practical, and effective specifically for university students.

METHOD

This study is a Research and Development (R&D) study adapting the 4-D model from Thiagarajan *et al*., (1974), consisting of Define, Design, Develop, and Disseminate stages. The research process began with the Define phase, which entailed a comprehensive analysis of needs, learners, tasks, and concepts, alongside a front-end analysis to establish clear learning objectives. Subsequently, the Design phase focused on selecting appropriate media and formats to create the initial prototype of the teaching materials, while also developing the necessary research instruments. During the Develop phase, the prototype underwent expert validation and a limited field trial to assess its feasibility and effectiveness. Finally, the Disseminate phase involved broader implementation within the Faculty of Teacher Training and Education to gather user feedback, followed by the distribution of findings through academic journals and national seminars.

The product trial in the Develop stage used a One Group Pre-test Post-test Design. Measurements were taken twice: before the treatment (pre-test) to determine initial ability, and after the treatment (post-test) using Ethno-STEM teaching materials. Although this design does not involve a control group, it is deemed appropriate for this R&D phase (limited field trial), where the primary focus is to evaluate the feasibility and initial impact of the prototype intervention rather than to generalize findings. To minimize threats to internal validity (such as history or maturation), the intervention was conducted intensively over a short period with strictly controlled material delivery.

The research subjects were divided into three distinct groups. The first group consisted of 6 expert validators. The second group comprised the field trial subjects (Develop stage), involving 25 students. The third group involved 30 students from the FKIP Unisla for the Disseminate stage. Student sample selection for the field trials was conducted using a purposive sampling technique. This technique was chosen because the participants were specifically enrolled in the Ethnoscience course, ensuring they possessed the necessary prerequisite knowledge to engage effectively with the Ethno-STEM teaching materials.

Data collection instruments developed in this study included expert validation sheets, student response questionnaires, local wisdom appreciation questionnaires, and creativity tests. Expert validation sheets were arranged using a Likert scale (1-4) to assess product feasibility from material, media, and language aspects. Student response questionnaires were used to measure the level of practicality of teaching materials, covering aspects of ease of use, clarity of instructions, and attractiveness. To measure the dimensions of recognition and understanding (cultural science recognition), affective attitude and appreciation (pride), and conative action and preservation (commitment to preservation), a local wisdom appreciation questionnaire adapted from the cultural literacy framework of Atmojo *et al*., (2025) was used. Additionally, a creativity

test in the form of essay questions was developed to measure aspects of fluency, flexibility, originality, and elaboration in the context of Ethno-STEM problem-solving.

Validity and practicality data were calculated using average percentages and analyzed descriptively quantitatively. The validity and practicality levels of the developed teaching materials are based on Table 1 and Table 2.

Table 1. Validity Criteria

Validity Percentage (%)	Criteria
$85 < V \leq 100$	Very valid
$70 < V \leq 85$	Valid
$50 < V \leq 70$	Less valid
$V \leq 50$	Invalid

Table 2. Practicality Criteria

Practicality Percentage (%)	Criteria
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Impractical
0 – 20	Very impractical

Furthermore, an effectiveness analysis was conducted to determine the increase in creativity and local wisdom appreciation using the Normalized Gain (N-Gain) test based on pre-test and post-test scores. The N-Gain was calculated using the formula developed by Richard R. Hake (Santoso *et al.*, 2025), as shown in the following equation:

$$\text{N-Gain} = \frac{Spost - Spre}{Smax - Spre}$$

The calculation results were interpreted into three categories, as shown in Table 3.

Table 3. N-Gain result criteria

N-Gain Percentage (%)	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

(Santoso *et al*., 2025)

In the Disseminate stage, user response data were collected from 30 students of the Faculty of Teacher Training and Education (FKIP) Universitas Islam Lamongan. This data was collected to determine student perception and acceptance of the developed teaching materials in a broader scope. Response questionnaire data were analyzed using percentage techniques, then the obtained scores were converted into student response eligibility criteria referring to Wijayanti & Antika, (2024) as presented in Table 4.

Table 4. Student response criteria

Student response Questionnaire Percentage (%)	Criteria
$80 < K \leq 100$	Very good
$70 < K \leq 80$	Good
$60 < K \leq 70$	Quite good
$50 < K \leq 60$	Poor
$K \leq 50$	Not Good

(Wijayanti & Antika, 2024)

RESULTS AND DISCUSSION

Development Results (Define & Design)

The Define stage began with a series of in-depth analyses, including front-end analysis, needs analysis at the research site, and formulation of development objectives. The front-end analysis identified a gap between 21st-century competency demands and learning realities, where the STEM approach is considered strategic for developing students' critical and creative skills Rahman *et al.*, (2023). However, its implementation is often less effective without cultural relevance, necessitating ethnoscience integration to create contextual learning (Siagian *et al.*, 2023). This is supported by findings that the reconstruction of scientific knowledge based on local wisdom effectively

improves learning quality (Putri *et al*., 2022; Sudarmin, Prasetya, *et al*., 2024).

Furthermore, needs analysis in the Science Education Study Program at UNISLA through RPS document analysis, student questionnaires, and lecturer interviews revealed the absence of structured Ethno-STEM teaching materials as a crucial problem. This finding aligns with similar obstacles at other educational levels Alfiana & Fathoni, (2022). Based on questionnaires to 25 students, a very high positive response was obtained regarding the urgency of developing these teaching materials, with 92% of students agreeing on the aspect of local wisdom appreciation, and 88% on the creativity aspect. These data indicate an urgent need for teaching materials capable of bridging abstract scientific concepts with cultural reality, while simultaneously reducing students' cognitive load (Reffiane *et al*., 2020).

From the lecturer's perspective, interviews confirmed difficulties in finding valid ethnoscience references and designing project-based learning from scratch, thus requiring a systematic and ready-to-use teaching materials. Data triangulation from curriculum documents, students, and lecturers confirmed that the development of Ethno-STEM teaching materials is not merely an option, but a fundamental need to achieve competent and character-driven graduate learning outcomes (Sudarmin *et al*., 2023). Therefore, the research objective was specifically formulated to develop Ethno-STEM teaching materials that are valid, practical, and effective in increasing students' appreciation of local wisdom and creativity.

Responding to these analysis results, the research proceeded to the Design stage by designing the initial draft of the teaching material titled "Ethno-STEM Teaching Material: Exploring Science, Technology, Engineering, and Mathematics in a Cultural Perspective". This design process referred to the findings of Mahbubah *et al.*, (2025), which emphasized the importance of a strong preliminary design in developing ethnoscience-based modules. To strengthen material relevance, concept analysis was conducted to map local wisdom into STEM disciplines. The results of reconstructing indigenous science into scientific science are presented as follows: (1) *Ikan pindang paciran* is used to explain thermodynamics concepts (heat preservation) and biology (osmosis) ; (2) *Batik sendang duwur* is integrated with chemistry concepts (natural/synthetic dyes) and mathematics (fractal geometry) ; and (3) The *subak* irrigation system was selected as a representation of "Nusantara Wisdom" for dynamic fluid materials and ecosystem balance, providing comparative insights for students beyond local Lamongan wisdom .

After the define stage formulated problems and needs comprehensively, the research continued to the Design stage focusing on two main activities: product design of teaching materials and preparation of research instruments to measure validity, practicality, and product effectiveness. The initial product design step began with compiling a teaching material outline that systematically integrates core STEM concepts with ethnoscience. This design was directed to arrange material flows and learning activities that are not only scientifically logical but also explicitly designed to stimulate increased student appreciation of

local wisdom and creativity. Based on this framework, the presentation format was set as a printed book with an ISBN output target. The initial draft (Prototype I) was compiled by presenting STEM material through concrete local wisdom case study contexts integrated with structured tasks. Figures 1, 2, and 3 below show the appearance of the developed teaching materials.

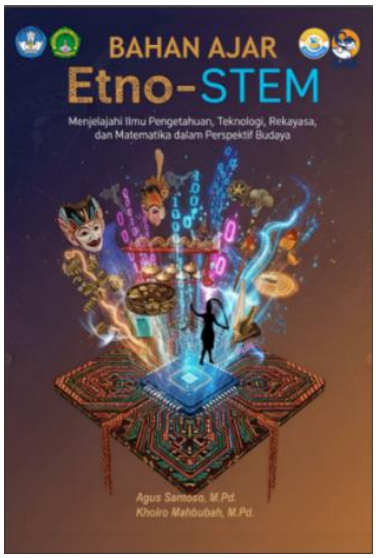


Figure 1. Ethno-STEM teaching material cover design



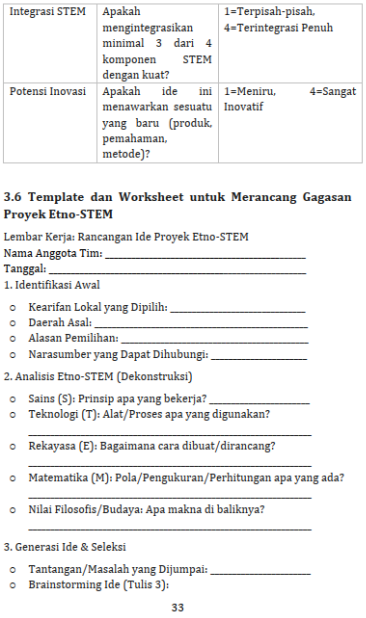
3.1 Teknik Identifikasi Potensi Kearifan Lokal untuk Proyek Sains

Langkah pertama adalah membuka mata dan telinga Anda untuk menjadi seorang ahli sains sekaligus detektif budaya. Jika memungkinkan observasilah potensi kearifan lokal yang ada disekitar tempat tinggal Anda. Berikut ini adalah Gambar proses pembuatan wingko babat dan batik sendang Paciran di Lamongan.

Gambar 3. 1 Proses pembuatan wingko babat di Lamongan
(Sumber: Jawapos.com)

Gambar 3. 2 Proses pembuatan batik tulis di Sendang Duwur Paciran Lamongan
(Sumber: Kolomdesa.com)

Figure 2. Content of teaching material



Integrasi STEM	Apakah mengintegrasikan minimal 3 dari 4 komponen STEM dengan kuat?	1=Terpisah-pisah, 4=Terintegrasi Penuh
Potensi Inovasi	Apakah ide ini menawarkan sesuatu yang baru (produk, pemahaman, metode)?	1=Meniru, 4=Sangat Inovatif

3.6 Template dan Worksheet untuk Merancang Gagasan Proyek Etno-STEM

Lembar Kerja: Rancangan Ide Proyek Etno-STEM
Nama Anggota Tim: _____
Tanggal: _____
1. Identifikasi Awal
- Kearifan Lokal yang Dipilih: _____
- Daerah Asal: _____
- Alasan Pemilihan: _____
- Narasumber yang Dapat Dihubungi: _____

2. Analisis Etno-STEM (Dekonstruksi)
- Sains (S): Prinsip apa yang bekerja? _____
- Teknologi (T): Alat/Proses apa yang digunakan? _____
- Rekayasa (E): Bagaimana cara dibuat/dirancang? _____
- Matematika (M): Pola/Pengukuran/Perhitungan apa yang ada? _____
- Nilai Filosofis/Budaya: Apa makna di baliknya? _____

3. Generasi Ide & Seleksi
- Tantangan/Masalah yang Dijumpai: _____
- Brainstorming Ide (Tulis 3):

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Figure 3. Ethno-STEM project worksheet

Simultaneously, data collection instruments were prepared, including validity, practicality, and effectiveness instruments. The expert validation instrument was designed as a structured questionnaire with a Likert scale to be filled out by six validators, consisting of two material experts (Ethno-STEM), two learning media experts, and two language experts. To measure practicality, a student response questionnaire was compiled assessing aspects of ease of use, attractiveness, and clarity of instructions. Meanwhile, to measure product effectiveness, two main instruments were developed. First, a local wisdom appreciation questionnaire arranged to measure dimensions of recognition and understanding (cultural science recognition), affective attitude and appreciation (pride), and conative action and preservation (commitment to preservation). Second, a creativity test in the form of essay questions designed to measure fluency, flexibility, originality, and elaboration aspects in the context of Ethno-STEM problem solving.

Develop

The development process began with a preliminary expert review, which yielded critical feedback for refining the Ethno-STEM prototypes. Experts highlighted the need to deepen the connection between STEM concepts and local wisdom through more concrete examples, while also advising a more systematic reorganization of the content. Furthermore, recommendations were made to enhance student engagement by integrating collaborative activities and simplifying the user guides. In response, the researchers revised the materials to explicitly link indigenous knowledge with scientific principles, improved the logical flow, and redesigned activities to foster interaction. Subsequently, a formal validation was conducted by specialists in subject matter, linguistics, and instructional media. Subject matter experts verified the content's accuracy and alignment with learning objectives, while linguists ensured readability and adherence to standard spelling (EYD). Simultaneously, media experts evaluated the visual design and technological integration.

The recapitulation of expert validation results is presented in Table 5.

Table 5. Expert Validation Result Recapitulation

Aspect	Validation Score (%) V1	V2	Average	Category
Material	90,0	92,0	91,0	Very Feasible
Language	91,7	80,0	85,85	Very Feasible
Media	92,5	87,5	90,0	Very Feasible
Rata-rata			88,95	Very Feasible

Generally, validation results from material content, language, and media aspects obtained an average score of 88.95%, meaning the developed teaching materials are in the "very feasible" category. This high validity aligns with findings by Listiyani *et al*., (2025), who reported that systematically developed Ethno-STEM-based learning tools have high content and construct validity due to strong cultural content relevance. This is also supported by Erman *et al*., (2023), stating that expert judgment on local wisdom-based science textbooks is crucial to guarantee material quality. The validation process by experts contributed significantly to the refinement of the teaching materials.

The expert validation process contributed significantly to the refinement of the teaching materials. Feedback from the validators encompassed comprehensive improvements across material, language, and media aspects to optimize the teaching materials. Regarding the material aspect, validators recommended the addition of practical implementation guides and clear assessment instruments, the inclusion of more concrete local wisdom case studies, and an update to the variety of references. In terms of the linguistic aspect, revisions focused on enhancing the consistency of writing style, the accuracy of punctuation and citations, and the refinement of diction to ensure the message was conveyed effectively and comprehensibly. Meanwhile, the media aspect required improvements in table and image layout, the addition of process visualizations to enhance engagement, and technical adjustments to image source citations and table formatting.

Valuable suggestions from the material, language, and media experts served as the foundation for the researchers to conduct comprehensive revisions. The provided suggestions,

ranging from content refinement to grammatical corrections and media presentation, were meticulously implemented to ensure the teaching materials achieved optimal quality. This collaboration between the development team and the experts reflects a commitment to producing teaching materials that are both effective and easily understood by students.



Figure 4. Learning using Ethno-STEM teaching materials

Classroom learning activities appear as shown in Figure 4. Based on testing results in the Develop stage (limited trial), the developed teaching materials showed a very high level of practicality. This is evidenced by a practicality test score of 88.33%, covering aspects of ease of use, instruction clarity, and product attractiveness, as shown in Table 6.

Tabel 6. Practicality Test Results

Aspect	Practicality Percentage (%)	Criteria
Ease of use	84,5	Very Practical
Instruction Clarity	90,5	Very Practical
Product Attractiveness	90	Very Practical
Average	88,33	Very Practical

Based on Table 6, the teaching materials were rated as Very Practical (88.33%) by students. Students felt the material was easier to understand using the teaching materials, and instructions were clear and interesting because they were close to daily life. This positive response is consistent with the study by Rizki *et al*., (2025), which found that the ethnoscience-based approach is viewed as a unique and culturally relevant method by learners, thereby increasing learning motivation. Practicality of teaching materials highlighting local wisdom was also confirmed by Martawijaya *et al*., (2023) in the development of local potential-based worksheets.

Besides being very practical, these teaching materials also proved effective in improving student competence. Field trials yielded effectiveness data on creativity and local wisdom appreciation presented in Table 7.

Table 7. N-Gain Result Criteria

Aspect	N-Gain	Criteria
Creativity	0,52	Medium
Local wisdom appreciation	0,71	High

The effectiveness of the teaching materials is evidenced by an improvement in creativity, indicated by an N-Gain score of 0.52 (medium category). This indicates that integrating local problem-based STEM project activities effectively stimulates students' fluency, flexibility, and originality in thinking. However, it should be noted that this assessment focuses on creative thinking skills evaluated through essay tests, rather than solely on physical engineering products.

The increase in creativity (N-Gain 0.52) can be attributed to the nature of the Ethno-STEM assignments which required students to re-engineer traditional

processes (e.g., preservation techniques) using modern STEM principles. This aligns with findings by (Rizki *et al*., 2025), who noted that cultural familiarity serves as a springboard for creative ideation. Unlike Western-centric STEM which often feels alien, Ethno-STEM allows students to modify and elaborate on existing local knowledge, thereby fostering originality and flexibility in their solutions. This finding aligns with Sumarni *et al*., (2025), who reported that a project-based Ethno-STEAM approach significantly increases the percentage of students categorized as creative. This is further supported by Nurhaliza *et al*., (2025), who indicate that integrated teaching materials are effective in fostering students' creative and collaborative thinking skills.The integration of technology in solving local problems also serves as a key factor, as demonstrated by Hakim *et al*., (2025), who integrated VR *lato-lato* into science learning.

The most significant improvement occurred in the aspect of local wisdom appreciation, achieving an N-Gain of 0.71 (High Category). This high score was driven by the strong integration of the cognitive dimension (recognition of cultural science), which subsequently stimulated the affective dimension (sense of pride). These teaching materials successfully reconstructed students' perspectives, shifting the view of local wisdom from mere tradition to a repository of scientific indigenous science. Sudarmin *et al*., (2024) emphasized that reconstructing indigenous science into scientific science is the core of the Ethno-STEM model's success. This increase in appreciation corroborates the findings of Atmojo *et al*., (2025), which demonstrated that STEM-based science learning integrated with ethnoscience significantly enhances cultural literacy. Furthermore, Sudarmin *et al*., (2025) found that the conservation character framework within Ethno-STEM is highly effective in instilling cultural values. Oladipupo *et al*., (2025) added that indigenous practices exert a strong influence on students' self-concept. As stated by (Sudarmin *et al*., (2024), this integration also enhances students' character of global diversity.

Disseminate

In the dissemination stage, the teaching materials were implemented more broadly to 30 students from the FKIP at UNISLA. The results of the user response questionnaire at this stage indicated an average practicality score of 87.5% (very good category). This confirms that the Ethno-STEM teaching materials possess consistent quality, are well-accepted by users beyond the limited trial group, and are ready for deployment as standard learning tools within the faculty. Overall, this study successfully addresses the gap identified by Abdurrahman *et al*., (2020) regarding the need for instruments that effectively integrate STEM dimensions with ethnopedagogy. These teaching materials serve not only as learning resources but also as a medium for cultural preservation that is adaptive to technological advancements.

CONCLUSION

This study successfully developed Ethnoscience-based STEM (Ethno-STEM) course teaching materials that have been tested as valid, practical, and effective. The product validity reached the very feasible category (88.95%), and its practicality was rated as very high (88.33%). The consistency of the product's

quality was further confirmed during the dissemination stage involving 30 students, yielding a user response practicality score of 87.50% (very good category). The implementation of the teaching materials proved effective in enhancing student creativity in the medium category (N-Gain 0.52) and significantly increasing the appreciation of local wisdom in the high category (N-Gain 0.71). For practical implementation in higher education, it is suggested that this Ethno-STEM approach be formally integrated into Semester Lesson Plans (RPS) and supported by specific lecturer training programs. This product is recommended as an innovative instructional tool in higher education to produce science educator candidates who are creative and culturally insightful. However, to strengthen these findings, future research should consider employing experimental designs with control groups, conducting longitudinal studies to assess the sustainability of cultural appreciation, and replicating the study in other cultural contexts.

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