Journal of Natural Sciences *ISSN 2721-5571 (Online)*
Vol.7 No.2 Juli 2026: 216-228 DOI: 10.34007/jonas.v7i2.1212

Development of an Ethno-STEM Based Module to Improve Creative Thinking Students in Conventional Biotechnology

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Submitted: 23 June 2026; Reviewed: 02 July 2026; Accepted: 24 July 2026

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Abstract

This study aims to develop an Ethno-STEM-based learning module to improve students' creative thinking skills in conventional biotechnology materials. The novelty this study lies in the integration Javanese local wisdom, particularly the tapai fermentation process, with STEM approach. The study used the Research and Development (R&D) method with the ADDIE model which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The research subjects consisted 31 ninth-grade students of SMP Swasta Sabilina. Data were collected through expert validation sheets, teacher and student response questionnaires, and creative thinking skills tests based on Torrance indicators. The validation results obtained Aiken's V score of 0.83 from material experts, 0.90 from design experts, and 0.91 from language experts, indicating that the module is very valid. The results of the practicality test showed teacher response of 95.2% and students 90%, so the module is categorized as very practical. The results of the effectiveness test obtained an N-Gain score of 0.13 which is included in the low category. These findings indicate that the module is valid and practical, but has not been effective in improving students' creative thinking skills. Therefore, improvements are needed by adding practice-based learning activities to increase the effectiveness of the module.

Keywords: Module Development; Conventional Biotechnology; Local Wisdom; ADDIE Model; Creative Thinking

How to Cite: Puandra, E.M. & Simatupang, H. (2026)***.*** *Development of an Ethno-STEM Based Module to Improve Creative Thinking Students in Conventional Biotechnology. Journal of Natural Sciences. 7(2): 216-228*

INTRODUCTION

Education is the cornerstone of developing high-quality human resources capable of contributing to national development. In the 21st century, students are expected to master essential skills, including critical thinking, creative thinking, communication, and collaboration (Mashudi, 2021). Among these, creative thinking is particularly important because it enables students to generate innovative ideas and solve problems effectively (Putri & Alberida, 2022). According to Torrance, creative thinking consists of four indicators: fluency, flexibility, originality, and elaboration (Reisman, 2019).

Despite its importance, Indonesian students' creative thinking skills remain relatively low due to internal factors, such as learning motivation and problem-solving ability, as well as external factors, including teaching approaches, instructional media, and learning materials that have not effectively supported creativity (Siregar et al., 2025). Creative thinking can be developed through learning experiences that encourage students to explore ideas, analyze information, and solve problems independently (Ningsih et al., 2025; Simatupang et al., 2024).

One promising approach is Ethno-STEM, which integrates local cultural knowledge with Science, Technology, Engineering, and Mathematics (STEM). This approach makes learning more contextual and meaningful while promoting higher-order thinking skills, creativity, and problem-solving abilities (Agustinus et al., 2025; Asrial et al., 2021). It also supports culturally responsive teaching by connecting scientific concepts with students' cultural backgrounds (Tanjung et al., 2023).

In this study, the traditional process of making Tapai was selected as the learning context because it represents Javanese local wisdom and illustrates conventional biotechnology concepts, such as microbial fermentation, yeast activity, and biochemical changes (Kamila & Tarunasena, 2022). Integrating this cultural practice into learning helps students relate scientific concepts to real-life experiences while preserving local knowledge.

Interviews with science teachers at SMP Swasta Sabilina revealed that students have low creative thinking skills and misconceptions about fermentation, including the differences between fermentation and decay, the role of microorganisms, and factors affecting fermentation. Moreover, the Ethno-STEM approach has never been

implemented, and learning materials are limited to textbooks and worksheets, indicating the need for more contextual instructional resources.

Previous studies have shown that learning modules can improve learning outcomes (Pramono et al., 2022). Although Lubis and Djulia (2026) developed a module to promote creative thinking, their study only examined its validity and practicality without testing its effectiveness. Furthermore, existing Ethno-STEM and biotechnology modules generally use local culture only as a learning context rather than integrating it systematically into all STEM activities. This indicates a research gap in developing modules that comprehensively integrate local wisdom while evaluating their validity, practicality, and effectiveness.

The novelty of this study lies in the development of an Ethno-STEM-based learning module that systematically integrates the traditional *tapai* production process into every STEM activity to create meaningful learning experiences and foster students' creative thinking skills. Therefore, this study aims to develop a valid, practical, and effective Ethno-STEM-based learning module for conventional biotechnology topics.

RESEARCH METHODS

This research was conducted at SMP Swasta Sabilina Tembung located on street Sabilina Pasar VII Tembung, Percut Sei Tuan District, Deli Serdang, North Sumatra. The research implementation time was in October – May of the 2025/2026 academic year.

This research is a research and development (R&D) using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model proposed by Reiser and Mollenda. The research subjects consisted of six expert validators, one science teacher, and 31 ninth-grade students of SMP Swasta Sabilina. The expert validators consisted of two material experts, two instructional design experts, and two language experts. The object of this research is an Ethno-STEM-based learning module on conventional biotechnology material for ninth-grade students of junior high school.

Validity of the module content was assessed by six expert validators using the Aiken's V coefficient. The Data obtained from the questionnaire answers in the form of checklists are summarized using a Likert scale as in Table 1 below.

Table 1. Assessment Criteria for Test Item Answers

No	Answer	Score
1	Very Good	5
2	Good	4
3	Pretty Good	3
4	Not Good	2
5	Not Very Good	1

The Aiken's V value was calculated using the formula:

$$V = \frac{\sum s}{n\,(c-1)}$$

Description:
V = Aiken validity index V
$s = r - l_o$
r = number given by the validator
l_o = lowest number
n = number of raters
c = number of categories selected by the rater

The score classification was then changed to percentages. Percentage criteria for the emergence of feasibility indicators sheet can be seen in Table 2 below.

Table 2. Percentage Criteria for the Appearance of Feasibility Sheet Indicators

Reliability Score	Criteria
0,8 - 1	Very high
0,6 – 0,79	High
0,40 – 0,59	Medium
0,20 - 0.39	Low

Practicality testing was conducted through a questionnaire containing teacher and participant responses. The questionnaire used a Likert scale with scoring levels as shown in Table 3 below.

Table 3. Criteria for assessing Teacher and Student Responses to Item Response Instruments

No	Results	Score
1	Very Good	4
2	Good	3
3	Not Good	2
4	Very Bad	1

The Data were then analyzed descriptively qualitatively by calculating the percentage of aspect indicators for each criterion of teaching materials developed using the formula

$$P = \frac{score\ obtained}{score\ maximum}\ x\ 100$$

The next stage is to convert the percentage of research data obtained into descriptive qualitative data using validation criteria as in Table 4 below.

Table 4. Criteria for Assessing Teaching Material

Average Score (%)	Description
≤ 25%	Impractical
26% - 50%	Not Practical
51% - 75%	Practical
75% - 100%	Very Practical

This module is implemented in a single class, and scores are calculated based on pretest and posttest scores. Pretest and posttest scores will be analyzed using the Swimmer test to ensure the data is normally distributed and homogeneous. In this study, the prerequisite tests used are normality and homogeneity tests using SPSS version 32. If the data is not normally distributed, a non-parametric test using the Wilcoxon Signed Rank test will be performed. In this study, the Wilcoxon Signed Rank test will be conducted using SPSS version 32.

Finally, the N-Gain test will be used to assess the effectiveness of this learning module in improving students' creative thinking. The Normalized Gain test is calculated using the following formula:

$$N - Gain = \frac{Post\ Test\ Score\ - Pre\ Test\ Score}{Ideal\ Score - Pre\ Test\ Score}$$

To determine the effectiveness of a learning module, scores are categorized into specific levels. For classification, the categories are typically adapted into a table like Table 5 where scores are divided into ranges such as high, medium, and low to reflect progress or mastery.

Table 5. Distribution of N-Gain Effectiveneess Test Scores

Score N-Gain	Categori
g < 0.3	Low
0.3 ≤ g ≤ 0.7	Currently
g > 0.7	High

RESULTS AND DISCUSSION

The development of these learning modules followed the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The results of each stage are described as follows:

Analysis Stage in this initial stage, the researcher conducted three stages of analysis, namely: curriculum analysis, creative thinking skills analysis, and learning needs analysis. The results of the curriculum analysis indicate that the school has implemented an independent curriculum. In conventional biotechnology materials, students not only learn concepts but are also asked to actively participate in practical activities aimed at improving their conceptual understanding and creative thinking skills. Learning in the context of local culture and integration with STEM has not been implemented. Analysis of creative thinking skills, based on the measurement scale, shows that the level of creative thinking skills is still in the low category, and teachers also stated that only a few students actively answer questions. Finally, the analysis of learning material needs revealed that teachers use textbooks and worksheets as learning resources during the learning process.

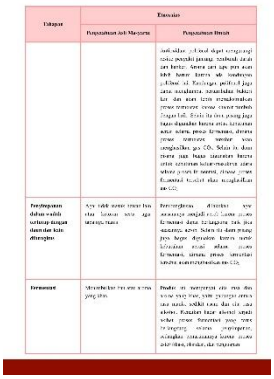
Design Stage, the Ethno-STEM-Based Module was designed using the Canva application. This application was chosen because it provides various features that support the development of learning materials, such as templates, themes, illustrations, icons, and a wide selection of fonts (Pratiwi & Nurrizalia, 2024). The module content was structured based on the previously conducted curriculum analysis. Furthermore, this phase also included the design of product validation assessment instruments, teacher and student practicality instruments, and assessment instruments to assess the effectiveness of the Ethno-STEM-based module in improving creative thinking skills.

According to Tanjung et al., (2025), the success of learning in fostering creativity can be measured through the use of appropriate assessment instruments that include creativity indicators. The creative thinking indicators used in the study refer to the Torrance indicators which include: fluency, flexibility, originality, and elaboration. 1) Fluency is an individual's ability to provide several relevant answers to a problem. 2) Flexibility is an individual's ability to provide various ideas from one approach to another. 3) Originality is an individual's ability to produce interesting ideas. 4) Elaboration is an individual's ability to provide more detailed explanations for the answers given.

Development Stage, after the product is designed, it is validated by validators using an assessment instrument. There are three expert validators: material, design, and language. This development phase is conducted twice. Revisions are made to achieve the highest level of feasibility for the module. The resulting data is then processed using the

Aiken V formula and categorized based on its feasibility level. The research results show that each validator's assessment received a high score, categorizing it as "Valid," meaning it is suitable for use in conventional biotechnology learning.

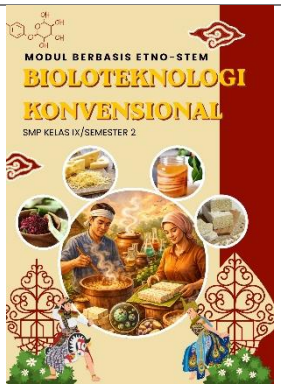
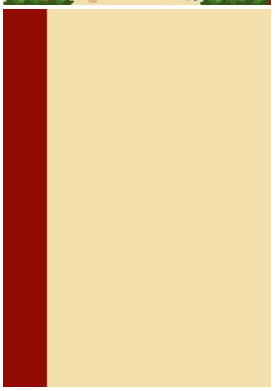
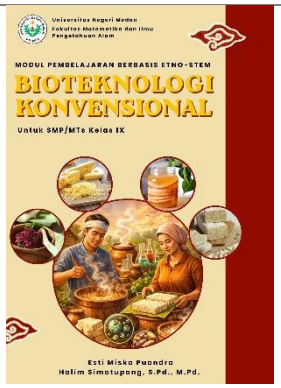
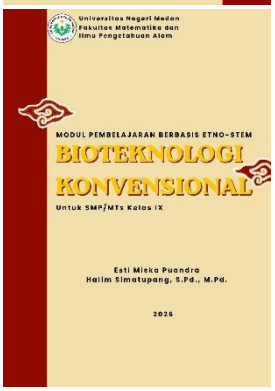
Table 6. Revisions by the Subject Matter Expert

Aspect	Suggestions for Improvement	Before Revision	After Revision
Accuracy of the Material	Revisions to several concepts related to fermentation, the microorganisms involved, and their roles in the process.		
Accuracy of the Material	Add the chemical formula for alcohol fermentation		
	Add a flowchart of the alcohol fermentation process		

Validation results by subject matter experts showed an average score of 0.83. The aspect of material alignment with learning objectives received a score of 0.88; the aspect of conceptual accuracy received a score of 0.78; and the aspect of the completeness of supporting materials in the module received a score of 0.88. Recommendations from the content validators emphasized that the module should include clearly formulated learning objectives and present the content in more specific units to make it easier for

students to master the material independently. This finding aligns with Thoib (2021) view, which states that one of the characteristics of a learning module is that it is self-instructional that is, the module's ability to enable students to learn the material independently without relying on assistance from others.

Table 7. Revisions by the Design Expert

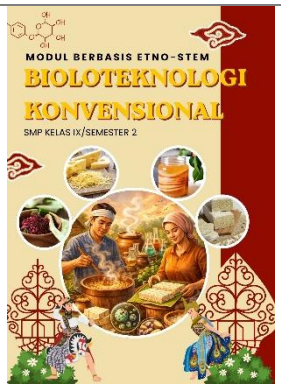
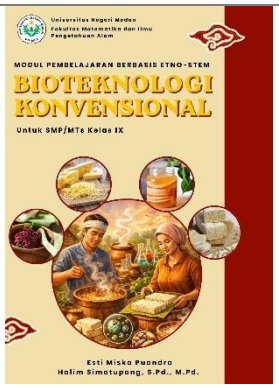
Aspect	Suggestions for Improvement	Before Revision	After Revision
Book Cover Design	Corrections to the front and back covers of the book	 	 

Validation results from design experts showed an average score of 0.90. The module size aspect received a score of 0.88, the cover design aspect received a score of 0.91, and the book content design aspect received a score of 0.91. Improvements made based on feedback from the design validators included adjustments to the layout, appropriateness of color combinations, and consistency in text style. This is supported by research by Kautsari et al., (2022), which states that the font used on the cover must be consistent with the background color, the use of color in concept maps must be consistent, and illustrations must be presented proportionally. An attractive layout and visual design can increase students' interest in using the learning module.

Finally, Validation results by language experts showed the highest average score of 0.91. In terms of language appropriateness for the learners' developmental level, the score was 0.88; for accuracy of language use, the score was 0.91; and for the coherence and

integration of the material presented in the module, the score was 0.94. Feedback provided by the language validators focused on improvements in writing and consistency in the use of italics for scientific names. The use of italics for scientific names aims to distinguish scientific terms in accordance with applicable writing conventions, namely that they should be italicized or underlined when written by hand (Ummah et al., 2021).

Table 8. Revisions by the Lingu Expert

Aspect	Suggestions for Improvement	Before Revision	After Revision
Language	Correct the title of the "Biotechnology" module		
	Consistency in writing Latin names in italics		

Implementation Stage, this stage is carried out to see the response from teachers and students to the module being developed. Student responses to the developed Ethno-STEM based learning module were gathered through two stages: a small scale pilot test and a large scale pilot test. Based on the results of the response questionnaire from the small scale pilot test, which involved 10 students, an average score of 83%. Next, the revised module was retested in a large scale pilot study involving 31 students. The results of the feedback questionnaire at this stage showed an increase in the average score to 88%, with the module rated as "Very Practical."

Although the module was rated as "very practical," the students are still provided several suggestions for improving it, including simplifying the language, adding supporting images to clarify the material, and providing a wider variety of practice

questions to help improve understanding of the concepts being studied. This increase in percentage indicates that the improvements were made based on student feedback during the small scale pilot test were able to enhance the quality of the module in terms of ease of use, time efficiency, appeal, usefulness, and clarity of language (Lubis & Baiduri, 2025).

The evaluation phase in this development research was conducted continuously at every stage of the development model, which included the analysis, design, development, and implementation stages, culminating in a final evaluation through testing the effectiveness of the Ethno-STEM based learning modules. The final evaluation was conducted by comparing students' creative thinking abilities before and after using the learning modules, based on pretest and posttest results. Since the research data were not normally distributed, further analysis was conducted using the nonparametric. According to Heryana (2023), data that are not normally distributed may be due to the presence of extreme values or outliers that differ significantly from the majority of the other data points.

Because the data obtained were not normally distributed, the Wilcoxon test was then carried out. The results of the Wilcoxon test showed a significance value of $p < 0.001$, which is less than the significance level ($\alpha = 0.05$); therefore, H_0 was rejected and H_a was accepted. The results indicate that there is a significant difference in students' creative thinking abilities before and after using the Ethno-STEM based learning module.

Next, an N-Gain analysis was conducted to determine the effectiveness of the Ethno-STEM based learning module in improving students' creative thinking skills. The analysis showed an average N-Gain score of 0.13, which is considered low. Although there was a significant difference between the pretest and posttest scores, the increase in students' creative thinking skills was still relatively low. Therefore, the module's effectiveness in improving creative thinking skills cannot be considered effective.

Limitations in the development of creative thinking skills can be influenced by several factors, including: time constraints, lack of project-based activities, and students' readiness for independent learning. According to Sutinah et al., (2025), students who are given sufficient and sustained learning time tend to have a better understanding of scientific concepts because they have the opportunity to engage in deeper cognitive processing.

In addition to time constraints, the lack of practical activities or projects can also hinder the development of students' creative thinking skills. Project-based learning provides students with the opportunity to explore ideas, develop alternative solutions, and create products as a way to apply their knowledge. According to Wafiyah et al., (2025), implementing project-based learning can improve students' creative thinking skills through the development of innovative ideas and the application of these ideas to create real products or solutions in science education. Students' readiness for independent learning is reflected in their belief in their ability to effectively plan, execute tasks, and achieve specific goals or objectives (Fitriani et al., 2024).

This study still has several limitations. The development of Ethno-STEM-based learning modules focused only on conventional biotechnology subtopics, using the tapaimaking process which is rooted in Javanese culture as the learning context. The issues addressed in the module are also limited to the effect of temperature on the fermentation process, and thus do not cover other factors that can influence the success of fermentation. Furthermore, the implementation of the module in this study did not involve hands-on laboratory activities, so the students did not gain learning experiences through actual experiments.

Therefore, future research is expected to develop modules covering a broader range of biotechnology topics by including examples of other conventional biotechnology products that can be integrated into the Ethno-STEM approach. Further research is also recommended to examine various other factors that influence the fermentation process and to integrate hands-on activities into the learning process so that students can gain a more meaningful learning experience and develop a deeper understanding of biotechnology concepts. In addition, a longer implementation period is needed so that the modules can be implemented more effectively, potentially leading to greater improvements in learning effectiveness.

CONCLUSION

Based on the research results, it can be concluded that the development of the Ethno-STEM-based learning module has met the criteria as a quality learning product, indicated by a very high level of validity based on the assessment of material experts, design experts, and language experts, as well as a level of practicality that is included in the very practical category based on the responses of teachers and students. These results indicate that the module is suitable for use as a learning resource in science learning to support a more active, independent, and contextual learning process. From the aspect of effectiveness, the

use of the module shows an increase in students' creative thinking abilities, but this increase is still in the low category based on the N-Gain test score category. Thus, although the module has been proven valid and practical for use in learning, its effectiveness in improving students' creative thinking abilities is stated to be ineffective. And still requires further refinement to provide a more significant impact.

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