

Building Students' Fluency and Flexibility through The Application of E-Learning Modules Integrated with Education for Sustainable Development (ESD)

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Abstrak

Penelitian ini bertujuan untuk meningkatkan keterampilan berpikir kreatif siswa, khususnya aspek fluency dan flexibility, melalui penerapan pembelajaran menggunakan e-modul bermuatan *Education for Sustainable Development* (ESD). Subjek penelitian terdiri dari 60 siswa kelas IX di salah satu SMP di Kabupaten Rejang Lebong. Penelitian ini menggunakan metode kuasi eksperimen dengan desain *pretest-posttest*. Instrumen yang digunakan berupa soal essay yang telah diuji validitas dan reliabilitasnya. Hasil penelitian menunjukkan adanya peningkatan signifikan dalam keterampilan berpikir kreatif siswa setelah penerapan e-modul bermuatan ESD. Peningkatan aspek *fluency* tampak dari meningkatnya kapasitas siswa untuk mengembangkan banyak ide dari satu isu yang didiskusikan, sedangkan aspek *flexibility* tercermin dari kemampuan mereka mengevaluasi masalah secara multidimensional dan merancang beragam solusi inovatif. Kesimpulan dari penelitian ini adalah penerapan e-modul bermuatan ESD efektif dalam meningkatkan keterampilan berpikir kreatif siswa, terutama dalam aspek *fluency* dan *flexibility*.

Kata kunci: e-modul, Education for Sustainable Development, flexibility, fluency

Abstract

This study aims to improve students' creative thinking skills, particularly in the aspects of fluency and flexibility, through the implementation of learning using an e-module enriched with Education for Sustainable Development (ESD) content. The research subjects consisted of 60 ninth-grade students from a junior high school in Rejang Lebong Regency. This study used a quasi-experimental method with a pretest-posttest design. The instrument used was an essay test that had been tested for validity and reliability. The results showed a significant improvement in students' creative thinking skills after implementing the ESD-enriched e-module. The increase in the fluency aspect was reflected in students' ability to generate multiple ideas from a single problem, while the flexibility aspect was evident in students' ability to view problems from various perspectives and produce diverse solutions. The conclusion of this study is that the implementation of ESD-enriched e-modules is effective in enhancing students' creative thinking skills, especially in the aspects of fluency and flexibility.

Keywords: e-module, Education for Sustainable Development, fluency, flexibility

INTRODUCTION

Education for Sustainable Development (ESD) is explicitly recognized in the Sustainable Development Goals (SDGs), particularly under Goal 4 on quality education. ESD equips individuals with the knowledge and skills not only to understand the SDGs but also to actively participate as informed citizens in driving transformative change (Rieckmann, 2017). According to Firth & Smith (2018), ESD adopts a holistic and interdisciplinary approach that fosters critical thinking, participatory decision-making, practical application, local relevance, pedagogical diversity, and the cultivation of values that support sustainability. Its core objective is to empower individuals and build capacity for future-oriented thinking and action.

Integrating the values of Education for Sustainable Development (ESD) into teaching and learning is essential for cultivating responsible individuals who can address global challenges, respect cultural diversity, and contribute to a more sustainable future (UNESCO Education Sector, 2010). Furthermore, the Indonesian Ministry of National Education Regulation No. 63 of 2009 on the Education Quality Assurance System emphasizes that school-based education should be grounded in the ESD paradigm to support the development of a sustainable society (Haerullah et al., 2019, 2025).

Incorporating ESD values into the learning process is essential. According to Segera (2015), instilling sustainability values from an early age is crucial to fostering students' awareness and commitment to preserving environmental, social, and cultural systems. Indrati and Hariadi (2016) highlight that one practical approach to implementing ESD in education is through the integration of its values into Biology instruction.

Biology instruction that incorporates ESD aims to support the development of students' creative thinking skills. Ahmad (2019) found that creative thinking has a positive impact on environmental management activities, as an individual's ability to analyze, identify, formulate, and draw conclusions from issues in their surroundings represents an indirect application of creative thought. Creative thinking is one of the essential 21st-century skills, specifically categorized under creativity and innovation. Through the development of creativity and innovation, it is expected that students will not only think creatively but also work creatively and produce novel innovations within the learning process (Wijaya et al., 2016). According to Trilling and Fadel (2009), creativity and innovation are cultivated in learning environments that foster curiosity, openness to new ideas, and the ability to learn from failure. Eldy and Sulaiman (2013) further assert that creative thinking is rooted in problem-solving attitudes, involving activities such as identifying problems, gathering data, formulating hypotheses, and communicating findings.

Torrance, as cited in Treffinger et al. (2002), explains that creative thinking skills include, among others, fluency and flexibility in thinking. According to Munandar (2009), fluency is characterized by the ability to generate numerous ideas, answers, questions, or problem-solving strategies, offering multiple ways or suggestions for accomplishing tasks. Flexibility, on the other hand, refers to the capacity to produce varied ideas, answers, and questions; to view problems from different perspectives; and to adapt approaches or ways of thinking.

"The implementation of Education for Sustainable Development (ESD) to support creative thinking skills in Indonesian schools is not a new concept; however, its execution remains suboptimal (Shantini, 2016). This aligns with the needs analysis conducted by the researcher on the application of ESD to enhance creative thinking in schools. The needs analysis was carried out through interviews with several teachers from various schools in Rejang Lebong Regency. These interviews aimed to gather information on the teaching materials used, the integration of ESD into Biology instruction, the use of technology in Biology learning, and the application of students' creative thinking skills in schools. The findings revealed that there are currently no learning resources specifically designed to support ESD-based instruction. Regarding creative thinking skills, it was found that teachers tend not to incorporate the indicators of creative thinking into their teaching practices. Most continue to use question development methods that do not adequately train students in higher-order thinking and remain largely focused on rote memorization. The interviews also served as a reference point for the author in determining which creative thinking indicators should be developed. The results suggested that, for the purpose of assessing creative thinking, several teachers recommended including only two indicators: fluency and flexibility. This recommendation was based on the teachers' experience, noting that students are not yet able

to think originally or demonstrate proficiency in elaboration. Fluency and flexibility were considered sufficient for fostering creative thinking at the junior high school level.

This teacher perspective aligns with the argument presented by Hanisch and Eirdosh (2023), who emphasize that for ESD implementation to have a meaningful impact in the learning process, educators must teach students not only about sustainability itself but also about human behavior. Moreover, teachers should guide students in becoming aware of and transforming their own behaviors through an interdisciplinary approach and metacognitive competencies—skills that are closely linked to fluency and flexibility in thinking.

Therefore, to cultivate creative thinking skills, it is necessary to implement instruction using an e-module as a learning resource embedded with ESD principles. The e-module should be designed to include both instructional content and practice questions that foster fluency and flexibility. The selected theme for this learning activity centers on traditional Indonesian fermented foods, a topic within the Conventional Biotechnology unit. According to Indrati and Hariadi (2016), biotechnology is one of the subjects well-suited for the integration of ESD values. The competency indicators associated with biotechnology are highly aligned with the principles of sustainable development, particularly in terms of applying biotechnology to support human life

METHODS

1. Research Objects and Subjects

The object of this research is the teaching material found in the E-learning module on the topic of Indonesian Traditional Fermented Foods, which is integrated with Education for Sustainable Development (ESD). The subjects of this study are 60 students from Grade IX at SMPN 1, Rejang Lebong Regency. This study was conducted during the 2021/2022 academic year in the second semester.

2. Instruments

The instrument used to measure students' creative thinking skills is the essay questions in the pretest and posttest, which were developed based on the indicators of creative thinking skills, namely fluency and flexibility. The test instruments consist of essay questions on creative thinking skills that have undergone validity testing, both construct and empirical, as well as reliability testing. The results of the validity and reliability of the test instruments are explained below.

Based on the validity test results, out of the 15 questions administered, only 10 were deemed valid, while the other 5 were considered invalid. Therefore, the questions deemed suitable for measuring creative thinking skills consist of 10 items. Based on the reliability calculation, the reliability coefficient of the instrument was found to be 0.72, which is considered high. This indicates that the instrument for measuring creative thinking skills in this study will yield consistent results if re-administered to students.

3. Data Analysis

After processing the data into scores, the next step is to calculate the normalized gain to determine the improvement that occurred before and after the use of the developed e-module. The calculation of the normalized gain uses the formula developed by Hake (1999), as shown in the following equation:

$$<g> = \frac{<posttest> - <pretest>}{<maximum> - <pretest>} \quad \dots(1)$$

Where:

<g> = N –gain

<pretest> = Mean pretest score

<posttest> = Mean posttest score

<maximum> = Highest score

The normalized gain value obtained shows the category of improvement in creative thinking skills. The N-gain data processing is conducted using SPSS software. The categorization of the N-gain score (gain index) can be seen in Table 1. below.

Table 1. Categorization of Normalized Gain (N-Gain) Scores

Value	Criteria
$(g) > 0,70$	High
$0,30 > (g) \leq 0,30$	Fair
$(g) \leq 0,30$	Low

Source: (Hake, 1999)

RESULTS AND DISCUSSION

The results of the improvement in students' creative thinking skills were obtained during the implementation phase. The results of this implementation were analyzed to assess the enhancement of creative thinking skills. Based on the data analysis conducted, there was a significant improvement in two categories of creative thinking skills: fluency and flexibility. The e-module integrated with Education for Sustainable Development (ESD) was designed with consideration of factors that could enhance creative thinking skills. The learning process emphasized exercises aimed at improving fluency and flexibility. The goal was to increase students' capacity to generate multiple ideas from a single issue, while cognitive flexibility was reflected in their ability to evaluate problems from a multidimensional perspective and to design various innovative solutions.

One of the activities conducted during the implementation of the e-module was a discussion aimed at solving the questions presented in the 'Ayo Lakukan' feature of Activity 2 in the Lemea material section of the e-module. In this activity, students engaged in group discussions with their peers, each group consisting of four students, to answer questions that were aligned with the indicators of creative thinking skills, with the help of a pre-prepared instructional video. This activity trained students to think flexibly and creatively when addressing a problem. Students were asked to elaborate their answers in detail and thoroughly.

The improvement in fluency and flexibility thinking skills in this study was measured using an essay test instrument that had been validated both constructively and empirically, proving it to be suitable for use. The analysis of the difference in the improvement of creative thinking skills was based on a comparison of pretest and posttest scores, analyzed using a scoring rubric. The categorization of the improvement in students' creative thinking skills was determined by calculating the normalized gain (N-Gain), which was then interpreted according to the criteria set by Hake (1999). The average pretest, posttest, and N-Gain scores for creative thinking skills can be seen in Table 2.

Table 2. Average Scores of Pretest, Posttest, and N-Gain

Score	Maximum	Average Scores			Criteria
		Pretest	Posttest	N-Gain	
60	100	40.3	82.9	0.71	high

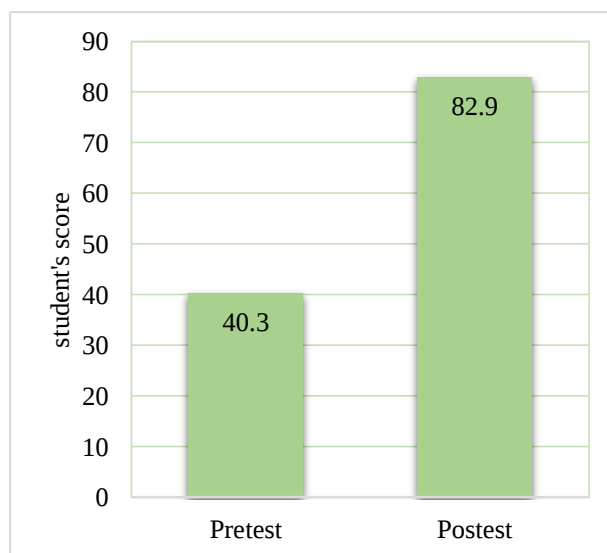


Figure 1. Diagram of the improvement in pretest-posttest scores of creative thinking skills

Based on the table and figure above, it is evident that there was an improvement in students' creative thinking skills after using the developed e-module. The improvement was also analyzed from the aspects of fluency and flexibility, both of which showed significant enhancement. The results of the improvement in each aspect are outlined in the following discussion.

This improvement indicates that the use of the e-module integrated with ESD can enhance students' creative thinking skills. This finding aligns with other studies related to the implementation of ESD in the learning process, such as Braßler & Schultze (2021) and Ito & Nakayama (2014), which argue that ESD is an interdisciplinary form of learning. Their research showed that an interdisciplinary approach is more effective in enhancing students' creative thinking abilities, including fluency and flexibility. Students engaged in interdisciplinary learning showed improvements in divergent thinking and the ability to generate various innovative solutions to sustainability issues. Further research by Hidayati (2020) and Nurfadilah & Siswanto (2020) also supports the idea that science education involving Education for Sustainable Development (ESD) can enhance creative thinking skills, including fluency and flexibility. The use of the ESD-integrated e-module provides stimuli for students to start thinking creatively and consider problem-solving strategies in environmental, socio-cultural, and economic contexts to achieve sustainable lifestyles. This is consistent with Ahmad's (2019) research, which suggests that creative thinking skills can have a positive impact on environmental management activities, where an individual's ability to analyze, identify, formulate, and draw conclusions about problems in the surrounding environment leads to the application of creative thinking in practice.

In addition to the implementation of ESD in learning, the use of the e-module also had a positive impact on the improvement of creative thinking skills. The developed e-module provided stimuli for students to explore multiple possible answers or ideas to address a given problem. This is consistent with research conducted by Romayanti (2020) and Linda & Putra (2021), which indicates that the use of e-modules in science education can enhance creative

thinking skills, self-learning, and student learning outcomes. Kimianti (2019) also stated that e-modules can serve as an alternative, practical, and contextual learning resource because they can be used anywhere, and the content presented is relevant to real-life situations.

The use of the ESD-integrated e-module to develop creative thinking skills is something new according to the students. One student, who achieved the highest score on the final test, expressed that the e-module used for learning greatly helped students focus on a single application, making it easier for them to study a science concept integrated with ESD. The student also mentioned that the materials, practice questions, images, and videos presented in the e-module enabled them to generate multiple ideas and thoughts when solving complex word problems.

Looking at previous research, it shows that the use of ESD-integrated e-modules can enhance creative thinking skills, which is one of the essential skills for the 21st century, along with other supporting components. This forms the basis for the researcher's assumption that the improvement in creative thinking skills is indicated to be caused by the ESD-integrated e-module developed, as it supports the development of creative thinking skills. The detailed assumptions about how the ESD-integrated e-module can enhance creative thinking skills are as follows:

1. The improvement in creative thinking skills after using the developed ESD-integrated e-module occurred due to the development process, product trials, and revisions that considered the quality and comprehensibility of the materials within the e-module. As a result, a high-quality, well-organized, and complex e-module product was produced. McDonald et al. (2017) highlight that the use of quality teaching materials is crucial for maximizing effective learning outcomes in science education.
2. The developed ESD e-module is contextual and has high complexity, which makes it easier for students to understand a concept. A study by Li et al. (2022) in Taiwan investigated the effectiveness of creative thinking teaching methods in the context of ESD with vocational students. The results showed that this approach significantly enhanced students' ability to generate diverse and innovative ideas and increased their engagement in learning.
3. The learning process is designed according to the principles of creative thinking skills, namely providing stimuli to students to always think fluently and flexibly, thereby generating various ideas and alternatives for problem-solving. Learning based on problem-solving or problem-based learning can improve students' creative thinking skills. This was evidenced by research conducted by Suparman, S., & Husen (2015) in one of the schools in Tidore Islands, where improvements were observed in fluency and flexibility in problem-solving-based learning.
4. The activities presented in the ESD-integrated e-module have been aligned with indicators that train fluency and flexibility thinking skills. According to Clark & Mayer (2008), students cannot develop the required abilities effectively unless they are trained. Therefore, the practice questions and final evaluations presented in the ESD-integrated e-module greatly assist students in becoming accustomed to thinking fluently and flexibly. López et al. (2024) state that sustainability-based learning that prioritizes creativity makes students more fluent in generating many ideas (fluency), more flexible in viewing problems from various perspectives (flexibility), more creative, collaborative, and willing to try new ideas, and better prepared for an uncertain future.
5. The learning materials are connected to real-life situations, making it easier for students to understand the problems they face and articulate alternative thoughts in solving them.
6. The learning process provides students with opportunities to actively engage through activities such as discovery, problem-solving, and discussion.

7. The presence of periodic learning evaluations for each activity in the e-module. Johnson and Adams (2011) explain that to support the development of creative thinking skills, evaluation activities must be conducted periodically. This is important because it allows teachers to improve their classroom management skills. Through evaluation activities, records of learning quality can serve as a reference for improving the quality of subsequent lessons.

Fluency

Creative thinking skills in this study refer to the model presented by Torrance in Treffinger et al. (2002), which explains that creative thinking skills include fluency, flexibility, and originality. However, this study only utilizes two indicators: fluency and flexibility. Awang & Ramly (2008) describe an aspect of creative thinking, namely fluency, as the ability to generate a large number of ideas. A strong fluency skill is characterized by the ability to quickly develop multiple solutions to a problem. The basic assessment criterion for this skill is the number of ideas or concepts that students can generate (Canel, 2015). The N-Gain calculation for the experimental class on the fluency aspect is presented in **Table 3**.

Table 3. Average Scores of Pretest, Posttest, and N-Gain for the Fluency Aspect

Score	Maximum	Average scores			Criteria
		Pretest	Posttest	N-Gain	
60	100	39.5	82.4	0.71	High

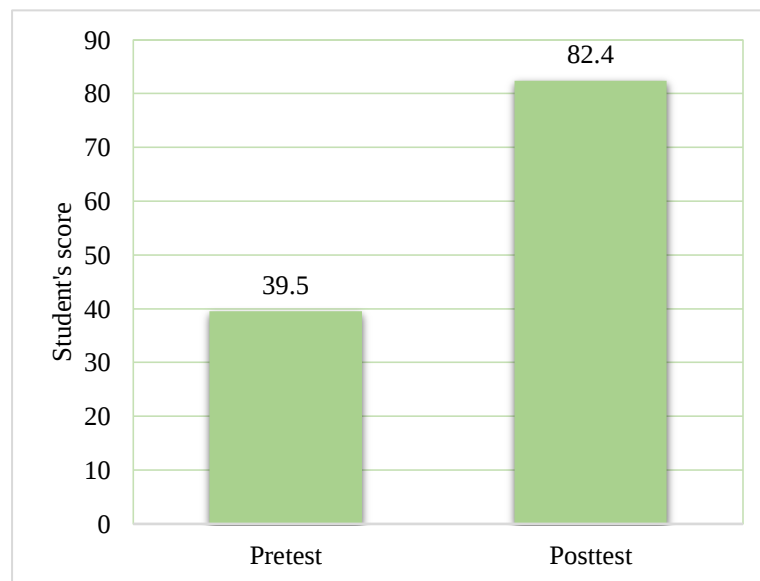


Figure 2. Diagram of the increase in pretest-posttest scores for the fluency aspect

The improvement in creative thinking skills in the tested class can be clearly seen in Figure 2. Based on Table 3 and Figure 2, it shows that the fluency aspect improved from the pretest to the posttest.

Based on the results obtained from the pretest, it is evident that students are not yet accustomed to answering questions with indicators of creative thinking skills, particularly fluency. For example, in question number 2 of the pretest, which asked about the reasons why fermented foods cannot be sold to other regions and how they could be sold without spoiling, most students provided only one answer. However, there are actually many possible reasons why fermented foods cannot be sold to other regions, as well as various ideas on how to

ensure their sale without spoilage. Another example of a question with a fluency indicator asked students to explain the causes of failure in the production process of fermented food (Lemea) and to outline the steps involved in making Lemea. The answers provided by students regarding the causes of failure in making Lemea were also limited to just one response, while 100% of the students gave incorrect answers regarding the correct steps for making Lemea. From this, it is clear that students are not yet familiar with questions that assess creative thinking skills or with materials that incorporate Education for Sustainable Development (ESD). In the context of traditional fermented foods, it also appears that students have limited knowledge about their own regional fermented foods. Furthermore, when answering creative thinking questions, students are still accustomed to rote memorization questions, which do not require higher-order thinking skills.

The results of the pretest assessment served as a reference for the researcher to identify areas of weakness in the process of answering questions related to creative thinking skills. These shortcomings were addressed during the implementation of the ESD-based e-module, where the content and exercises were designed to integrate the creative thinking indicators, particularly fluency. During the implementation process, the researcher formulated several activities to be conducted while applying the ESD-based e-module. These activities are outlined in the explanation below.

1. Before the lesson begins, the teacher can assign reading tasks about the content to be discussed in the next session, which can be found in the ESD-based e-module.
2. The teacher emphasizes to the students the importance of actively exploring all the menus in the e-module to gain a comprehensive understanding, including paying attention to the images and videos provided.
3. The teacher must be able to effectively reconstruct students' understanding through statements that encourage students to ask questions.
4. The teacher can conduct reflection activities on the entire learning process to ensure that the material taught is retained and can be revisited in the following sessions.
5. The teacher must reiterate and ask students to be meticulous in presenting ideas and answering questions, not just providing one possible answer.

The implementation process of the ESD-based e-module proceeded effectively, and students were able to use the module properly. In addition to using the e-module, students were actively encouraged to participate in the learning process both in groups and individually. After three sessions of implementing the ESD-based e-module, students were given a final test (posttest). The results of the posttest indicated an improvement in fluency-related creative thinking skills. Students began to provide multiple answers to problem-solving questions rather than offering only a single response. Furthermore, students demonstrated accurate responses to questions related to ESD content.

Based on the results obtained, it can be concluded that the use of the developed ESD-based e-module—designed with indicators of creative thinking, particularly in the aspect of fluency—and its integration with learning activities that actively engage students both intellectually and socially, can enhance students' fluency thinking skills. This finding aligns with previous studies by Atmojo (2012), which stated that learning processes that actively involve students through innovative and enjoyable instructional strategies can foster students' ability to think fluently.

Flexibility

The characteristics of flexibility thinking skills include the ability to generate diverse ideas and responses, view a problem from different perspectives, and explore multiple

alternatives for problem-solving (Awang & Ramly, 2008). Canel (2015) stated that strong flexibility is indicated by an individual's capacity to propose the most appropriate solutions derived from analyzing various perspectives. The N-Gain calculation for the experimental class in the flexibility aspect is presented in Table 4.

Table 4. Average Scores of Pretest, Posttest, and N-Gain for the Flexibility Aspect

Score	Maximum	Average Scores			Criteria
		Pretest	Posttest	N-Gain	
60	100	41.4	83.8	0.72	High

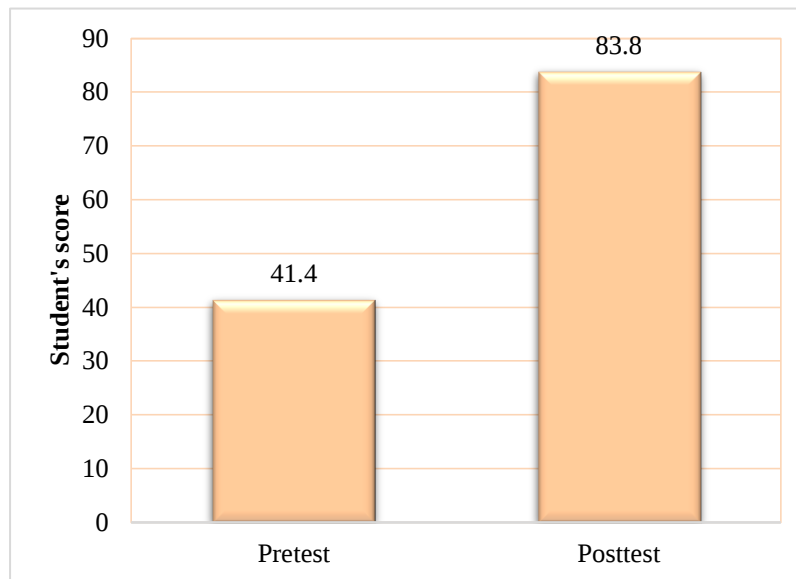


Figure 3. Diagram of the increase in pretest-posttest scores for the flexibility aspect

The improvement in students' creative thinking skills in the tested class can be clearly observed in Figure 3. Based on Table 4 and Figure 3, it is evident that the flexibility aspect showed an increase from the pretest to the posttest.

Based on the results presented in the table and figure, it can be concluded that students were not yet accustomed to answering questions that involve the creative thinking skill indicator of flexibility. For example, in pretest question number 1, students were asked: "A village is experiencing a food crisis leading to hunger. The village chief instructs the community to make fermented food from young bamboo shoots, which can be used as a nutritious side dish. The village happens to have many bamboo forests. In your opinion, why did the village chief ask the villagers to make fermented food from bamboo shoots? Write your opinion about the benefits of fermented food." In responding to this question, students did not provide detailed explanations or offer well-developed ideas. The responses indicated that students were unfamiliar with open-ended, scenario-based questions requiring flexibility in thinking. This is further supported by students' own statements that they were more accustomed to answering rote memorization-type questions typically used in their learning process.

Another example of a question developed based on the flexibility indicator is: "Group 3 was assigned to make tape (fermented cassava) in a lesson on the application of conventional biotechnology. The type of tape to be made by this group is cassava tape. Naturally, the essential ingredients are cassava and microorganisms or yeast for fermentation. The students had followed the steps for making tape according to the instructions. However, the resulting tape was not suitable for consumption. In your opinion, what might have caused

the tape product to be unsuitable for consumption?" In responding to this question, students generally provided only one answer. In fact, there are many possible causes for the failure of the tape product when viewed from various perspectives. Based on an analysis of students' answers to both questions, it is evident that they are not yet proficient in solving questions that assess creative thinking skills related to flexibility.

Similar to the fluency aspect, the flexibility aspect in the pretest was evaluated to identify areas that students found difficult to understand. The results of this evaluation were then used as a reference for teachers in the implementation process of the ESD-integrated e-module. The evaluation steps are outlined as follows:

1. Prior to the learning session, teachers may assign students to read the content to be discussed in the next meeting, which is provided in the ESD-integrated e-module.
2. Teachers train students by providing a set of questions aligned with the *flexibility* thinking indicator and guiding them on how to approach and answer such questions.
3. Teachers remind students to actively and thoroughly read the materials in the e-module, including examining images, supplementary informational texts, and videos.
4. Teachers may conduct reflection activities on the learning outcomes to reinforce the material for future lessons.
5. Teachers should re-emphasize the importance of being thorough when proposing ideas and encourage students to provide more than one possible answer to a question.

After the implementation of the e-module, students were given a final test (posttest). Based on the posttest results, there was a noticeable improvement in students' flexibility thinking skills. Students began to provide more than one response when solving problems and were able to offer multiple solutions. For instance, in response to a question regarding Group 3's attempt to make cassava tape, which failed despite following correct instructions, students were able to identify several possible causes for the failure. Their answers reflected a variety of ideas and perspectives, indicating enhanced flexibility in their thinking.

Effective teaching strategies are essential in developing creative thinking skills. Effective teaching strategies include student-centered activities, learning content related to everyday life, good classroom management, open-ended questions, motivating students to think creatively, and the use of technology and multimedia. A positive classroom environment can enhance creativity by providing students with a range of choices, accepting diverse ideas, boosting self-confidence, and focusing on students' strengths and interests (Trna & Trnova, 2013).

CONCLUSIONS

Based on the analysis, findings, and discussions that have been presented, it can be concluded that the improvement in students' creative thinking abilities in the aspects of fluency and flexibility, using the E-modul embedded with ESD on the theme of Traditional Indonesian Fermented Foods, falls within the high criteria.

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