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Improving Student's Creative Thingking Skills Using Worksheets Based STEM-Project

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Abstract: This study aims to determine the characteristics, teacher and student responses, and the effectiveness of STEM-PjBL-based LKS on the material of making peuyeum to improve creative thinking skills in the developed biotechnology material. The method used is a mixed method with an embedded experimental model. This study involved 10 biology teachers and 20 students in Lampung Province at the pre-intervention stage and after the intervention involving 32 grade X students of SMA Negeri 3 Bandar Lampung and 2 teachers as research observers and 1 teacher as a teacher. Data collection was carried out through a LKS validation questionnaire on the aspects of material suitability, construction, and readability for experts, a teacher response questionnaire covering material suitability and readability, and a student response questionnaire after implementing learning using STEM-PjBL-based LKS, as well as a set of pretest-posttest instruments for creative thinking skills. The data analysis technique in this study used the paired sample t-test. The average percentage of expert validation results for the material suitability aspect was 89.77%, construction 90.62%, and readability 87.50% so that the STEM-PjBL-based peuyeum making worksheet was declared valid and had a "very high" criterion according to Arikunto's assessment standards with characteristics following the STEM-PjBL syntax and containing local wisdom in the form of peuyeum. The teacher's response to the material suitability aspect was 93.18% and readability 91.66% and the average student response was 84.81% so that the worksheet was suitable for use in biology learning with a "very high" criterion. The results of the paired sample t-test stated that there was a significant difference between the pretest (41.85) and posttest (72.99) scores of students, so that the STEM-PjBL-based peuyeum making worksheet that was developed effectively improved creative thinking skills.

Keywords: Creative thingking skills; Peuyeum; STEM-PjBL

Introduction

Partnership for 21st Century (2009) states that improving students' skills and innovation is recognized as readiness to face an increasingly complex living and working environment. Moreover, it is related to the ability to overcome a problem that requires creative ideas. Trilling et al. (2009) state that there are four skills that students must have to face the challenges of the 21st century, namely critical thinking and problem solving, communication, collaboration, creativity and innovation. Creative thinking skills is one of the skills in the 21st century that must be developed to make students more prepared to face increasingly stringent global demands. In the process of improving creative thinking skills in terms of creating new ideas, students indirectly need the abilities to analyze, evaluate, collaborate, and convey these ideas. So indirectly, in training creative

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thinking skills, critical thinking skills and problem solving, communication, and collaboration are needed. These creative thinking skills can orient someone to use various methods with different perspectives, have new thoughts, and an ability that is used to guide in producing or choosing an alternative solution (Torrance et al., 1992). Students with trained creative thinking skills will be able to be flexible and able to see opportunities in facing the rapidly developing global challenges (Ritter & Mostert, 2017).

One way to equip students with these skills is to improve the quality of education in Indonesia. Improving the quality of education in Indonesia based on the results of the analysis of the achievement of sustainable development goals (SDGs) is an important step in supporting the development of a better and sustainable education system (Bogoviz et al., 2022). The purpose of Sustainable Development Goals (SDGS) is to develop "quality education", this is in the sense that every student must obtain the knowledge and skills needed to promote sustainable development (Kopnina, 2020). Quality education aims to foster students to become creative and responsible world citizens who critically reflect the idea of sustainable development and the underlying values (Spanring, 2019). Another problem was also experienced by the Science Education System in the world which is faced with global challenges to anticipate environmental changes related to Sustainable Development Goals (SDGs) (Abdurrahman et al., 2023). Based on this to achieve the goals of quality education and environmental changes, the existing education system must be created with the environment and a pleasant learning process that encourages students to develop their skills to the maximum (Nurfatimah et al., 2022).

Biology is one branch of science learning that is oriented to equip students in facing life challenges in the 21st century (Lina 2023; Suprapto et al., 2018). Biology learning is defined as the study of living things and problems related to life. This learning has characteristics in the form of facts, concepts, principles, laws, and procedural knowledge in the form of knowledge about how to obtain information, ways of science and work technology, scientific work habits, and thinking skills (Azzahra et al., 2023). The nature of biology learning has similarities with science learning. Science learning can be defined as a process, attitude, and scientific product that must be done by scientific investigation to foster thinking skills. In science learning, students must carry out thinking activities and a series of processes to find new facts, concepts, and knowledge (Handayani et al., 2021). Creative thinking skills in biology learning not only put forward new ideas, but also design contextual solutions and adapt to real challenges. Through this, biology learning that integrates creativity directly realizes quality education that is contextual and relevant in accordance with the SDGs.

In the field of education today, there are several challenges related to the lack of utilization of learning media and the less than optimal implementation of the learning models used. Currently, there are still many teachers who use conventional learning, so that teachers dominate the learning process (Imaroh et al., 2022). According to Iryanti (2021), several problems occur in the current learning process, namely the lack of variation in learning models used by teachers, so that teachers dominate learning and the lack of use of learning media which causes students to feel bored when learning takes place. Learning that tends to be dominated by teachers like this will limit students in the development of their thinking, including creative thinking skills (Sari et al., 2019). Therefore, it is necessary to apply a learning model that is oriented towards improving students' creative thinking skills.

One way that can be used to develop creative thinking skills is through design challenge project work, where students must find solutions to real-world problems (Trilling & Fadel, 2009). Project Based Learning (PjBL) is a curriculum-based contextual learning based on real questions or problems that involve students in selecting topics, considering approaches, designing, solving problems, making decisions, providing opportunities to work freely for a long time and producing real products related to the problem (Diawati et al., 2017). Project-based learning can encourage students to be more active in learning and increase student' scientific creativity (Fadiawati et al., 2021; Fatma, 2021). PjBL learning is a learning process that directs students to problems directly, then the solution involves project work that is indirectly active and trained to act and think creatively (Kusadi et al., 2020).

The implementation of Project Based Learning (PjBL) learning model activities requires knowledge that supports the implementation process, namely an approach to learning. One approach that can be used to help this process is the STEM approach. The STEM approach focuses on the moral imperative of education to prepare students to live effectively and contribute to a better global society by preparing students who can respond effectively to various economic, social and environmental challenges by involving aspects of science, technology, engineering, and mathematics (Corrigan, 2020). In its implementation, the STEM approach can be implemented with the Project Based Learning (PjBL) learning model.

Learning using STEM-PjBL can support future careers, improve scientific literacy, motivate students, improve understanding of the material, improve creative thinking skills, and make learning more meaningful because it is connected to problems in everyday life (Agung et al., 2022). STEM-PjBL learning can encourage students to understand concepts through problem identification and product creation as solutions to these problems (Laboy-Rush, 2011). Laboy-Rush (2011) also stated that the advantages of implementing PjBL-STEM include the transfer of knowledge and skills to real-world problems, increased motivation to learn, and increased knowledge of mathematical and scientific concepts.

The application of the STEM-PJBL stages in learning can be integrated through LKPD (Student Worksheet). Development of creative thinking skills in LKPD is carried out by means of students given a challenge to make a local-based product in learning. The focus of improving creative skills in socioscientific issues is relatively rare, and is a major concern in research. In addition, in the integration of the SSI approach with the Stem-PJBL model it has not been explored comprehensively in the context of learning in Indonesia (Tasyani et al., 2025). Cassava is an agricultural commodity and is widely planted in Indonesia as a source of carbohydrates and energy. One product made from cassava is Peuyeum. Peuyeum has a distinctive and soft aroma, taste, and texture (Fatmawati et al., 2019).

Peuyeum is one of the local wisdom in the form of biotechnology products in the food sector. Biotechnology is a branch of biology that uses living things in industrial processes (Campbell, 2013). Biotechnology has existed since humans began manipulating the natural environment to increase food and health supply, for example bread and cheese (Clark & Pazdernik, 2015). Biotechnology can be divided into two, namely traditional and modern biotechnology. Conventional biotechnology utilizes living things to produce to produce products without genetic manipulation, examples of making cheese, wine, tempeh, and tape. Whereas modern biotechnology utilizes biological agents or its components that have experienced genetic engineering through recombinant DNA technology to produce goods and or services to meet human and environmental needs, for example cloning (Darmayanti et al., 2021). Peuyeum is a cassava-based dish that is processed by the fermentation process, so as to produce a distinctive aroma and taste (Rakhmani et al., 2023). Based on this, peuyeum is one example of conventional biotechnology. Based on this, peuyeum is one example of conventional biotechnology. The making of peuyeum involves aspects of science, one of which involves yeast as an aspect of microorganisms in biology, peuyeum making techniques using incubators, temperatures, and the right pH, engineering aspects that include packaging/tool engineering for tape fermentation, and mathematics that includes calculation methods for each variable that produces a sweet peuyeum taste and the right texture.

In addition to having the goal of improving the quality of education, SDGs aim to eradicate poverty, minimize inequality, and protect the environment (Pangestu et al., 2021). This is in line with the eighth SDG goal, which is related to decent work and economic growth. This goal seeks to encourage the creation of sustainable, inclusive economic growth followed by productive employment and decent work for every individual (Nialda et al., 2022). Thus, making *peuyeum* can be used as one of the challenges that can be used in learning and is expected to improve the economy and improve the welfare of an individual. Based on this, researchers developed STEM-PjBL-based worksheets for making *peuyeum* to improve students' creative thinking skills. So the researcher will examine the characteristics, teacher responses, and effectiveness of STEM-PjBL-based worksheets for making peuyeum to improve students' creative thinking skills.

Method

The development of STEM-PjBL based LKS for making peuyeum uses a mixed method with an embedded experimental model design. Mixed research is a research method that combines two forms of research or a combination of qualitative and quantitative research (Creswell, 2008). Embedded experimental design is a mixed research design where qualitative data is collected and analyzed in an experimental design. Qualitative and quantitative data can be collected simultaneously or sequentially, but qualitative data will support quantitative data. In this study, researchers collected qualitative data before, during, or after the intervention to support quantitative data. Data collection before the intervention will help design interventions that are tailored to students in the form of preliminary study data on teacher and student needs and validation data from LKPD for experts and teachers. The stage during the intervention obtained quantitative data in the form of pretest-posttest scores. Post-intervention data collection can help explain and follow up on the results of quantitative data in the form of student response questionnaire data. The data sources in this study before the intervention were 10 science teachers and 20 students in Lampung Province, and data during and after the intervention involved 32 grade X students of SMA Negeri 3 Bandar Lampung.

The instruments to be used in this study include teacher and student response questionnaires, worksheets validation instruments for aspects of material suitability, construction, readability, pretest-posttest questions for creative thinking skills. Qualitative data analysis techniques in the form of validation of the suitability of the content and construction of the project-based learning program for making peuyeum to improve creative thinking skills were obtained using responses. The data analysis techique in this study used SPSS 26.0 software when obtained normal data then using the paired sample t-test, if the research data is not normal then the Wilcoxon test can be used. The mixed method research procedure with an embedded experimental model design is shown in Figure 1.

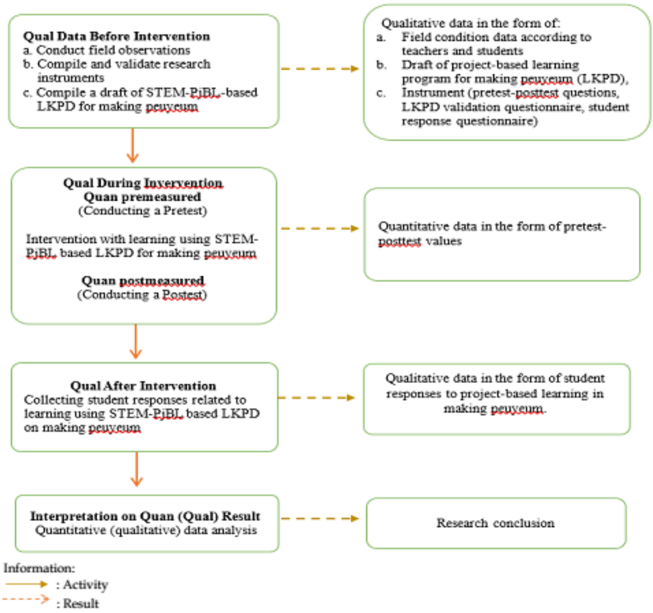


Figure 1. Research procedures

Result and Discussion

Research and development of STEM-PjBL-based worksheets products for making *Peuyeum* were carried out based on the stages of the mixed method development with the Embeded Experimental Model research design, which includes qual before intervention, qual during intervention, and qual after intervention.

The first stage in this study is qual before intervention. This stage includes the collection of qualitative data in the form of field observations to teachers and students, the preparation of drafts of project-based learning programs, and worksheets validation questionnaires for aspects of material suitability, construction, and readability. This stage was carried out with the aim of collecting data and information for the development of STEM-PjBL-based LKPD for making *peuyeum*. The results of field observations on the distribution of questionnaires to 20 students from 5 high schools in Lampung are presented in Table 1 and 10 Biology teachers from 4 high schools in Lampung are presented in Table 2.

Based on Table 1, it is obtained that students have learned about biotechnology based on the learning materials taught in class. There were 10 student respondents who stated that biotechnology is a branch of science that utilizes living things to produce a product that is useful for humans. This statement is supported by the results of the teacher needs analysis questionnaire in Table 2. All teachers in this research subject stated that they had taught biotechnology material to students through worksheets or other methods. This statement is in line with the answers of students who stated that students (70%) had learned this biotechnology material with worksheets, but some of the students (55%) still had difficulty in learning biotechnology material. This was explained by 3 students who stated that they did not understand the basic concepts of biotechnology and the biotechnology products developed were not appropriate. Based on this, it turns out that 70% of teachers who use the worksheets are the results of downloading from the internet.

Table 1. Results of Field Observations of Students

Information	Percentage (%)
Students have learned about Biotechnology	90%
Students have been taught Biotechnology material	85%
Students have difficulty in learning Biotechnology	55%
Students have learned to use worksheets	85%
Biotechnology processed products studied at school	30%
a. Tempe	45%
b. Cassava tape	20%
c. Sticky Rice Tape	

Table 2. Results of Field Observations of Teachers

Information	Percentage (%)
Teachers have taught biotechnology	100%
Teachers have taught biotechnology using worksheets	70%
Workheets used in learning is the result of downloading from the internet	70%
Processed biotechnology products taught in schools	80%
a. Tempe	70%
b. Cassava tape	70%
c. Sticky rice tape	

So the worksheets used includes making tempeh (30%), making cassava tape (45%), and making sticky rice tape (20%). On the other hand, teachers have taught biotechnology associated with processed products in everyday life such as tempeh (80%), cassava tape (70%), and sticky rice tape (70%). This is in line with the results of the teacher questionnaire which stated that teachers had never linked the process of making *peuyeum* in the worksheets, so that 100% of teachers stated that it was necessary to develop a STEM-PjBL-based worksheets for Making *Peuyeum* to improve the creative thinking skills of high school students. The results of this preliminary study are in line with research which states that most teachers show a positive perception of the development of STEM-PjBL integrated worksheets in improving students' creative thinking skills (Tasyani et al., 2025).

After conducting field observations, the researcher drafted a STEM-PjBL-based learning program for making *peuyeum*. The draft of the learning program that was prepared included the preparation of teaching modules, pretest-posttest question instruments, pretest-posttest grids, and assessment rubrics, then the researcher compiled a worksheets validation questionnaire covering aspects of construction, material, and readability. Furthermore, the final worksheets draft entered the expert validation stage by lecturers and teacher response tests. The validation process was carried out to determine whether the developed product was feasible or not (Arikunto, 2013). The results of the worksheets validation are shown in Table 3 and teacher responses are shown in Table 4.

Table 3. Results of Worksheets Validation by Experts

Validation Aspects	Percentage (%)
Suitability of materials	89.77%
Suitability of construction	90.62%
Readability	87.50%

Table 4. Results of Teacher Responses to Worksheets

Validation Aspects	Percentage (%)
Suitability of materials	93.18%
Readability	91.66%

Based on Table 3 and 4. Information was obtained that the STEM-PjBL-based worksheets for making *peuyeum* in terms of material, construction, and readability aspects obtained valid results for use with the criteria of the percentage of the criteria "Very High". The results of teacher responses obtained that the worksheets developed in terms of material and readability aspects obtained responses with the criteria "Very High" and is suitable for use as an alternative teaching material in learning. This is because the STEM-PjBL-based worksheets for making *peuyeum* has included characteristics in the form of material and indicators that are formulated in accordance with learning outcomes (CP) according to the independent curriculum, in addition, the suitability of the worksheets to improve creative thinking skills is in accordance with the syntax and steps of STEM-PjBL learning according to Laboy-Rush (2011). The student worksheets that have been developed contain local cultural wisdom in the community, namely *peuyeum* so that in their learning it is already contextual to what students experience in their environment. Therefore, learning using this student worksheet is expected to form effective two-way interactions between teachers and students so that learning objectives can be achieved.

The next stage is qual during intervention, this stage is the stage of implementing STEM-PjBL-based worksheets products for making *peuyeum* to improve students' creative thinking skills. The instrument used in this study was the pretest-posttest questions for creative thinking skills. The pretest-posttest data that had been obtained were then processed using Microsoft Office Excel 2013 software and analyzed using SPSS Version 26.0 for Windows. The pretest-posttest value data for students' creative thinking skills are shown in Table 5.

Table 5. Pretest-Posttest Values of Students' Creative Thinking Skills

Average value		Pretest-posttest increase
Pretest	Postest	
41.85	72.99	31.14

Table 6. Results of the n-Gain Normality Test of Students' Creative Thinking Skills

Average value		Average n-Gain	Sig. test of Normality
Pretest	Postest		Kolmogorov-Smirnov
41.85	72.99	0.53	0.20

Table 7. Results of Paired t-Test of Students' Creative Thinking Skills

Average value		Average n-Gain	Sig. (2- tailed)
Pretest	Postest		
41.85	72.99	0.53	0.000

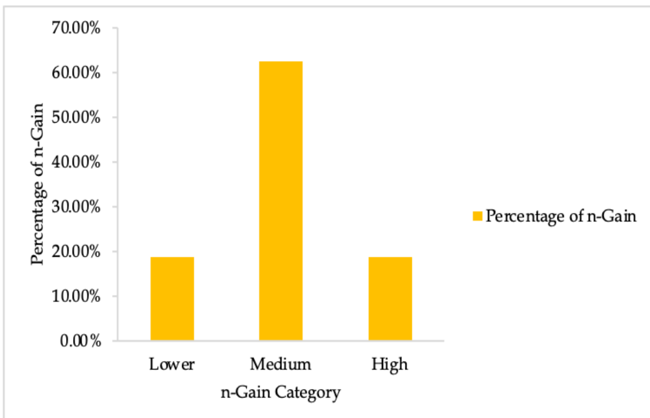


Figure 2. Percentage of each student's n-gain value criteria

Based on Table 5, information was obtained that there was an increase in the average value of students before and after the implementation of STEM-PjBL-based worksheets learning in making *peuyeum* in the classroom. This increase occurred because in learning using STEM-PjBL, students were invited to practice their thinking skills, starting from thinking fluently, thinking flexibly, planning original products, and elaboration (Mamahit et al., 2020). In line with this, it can be seen in Figure 2. that the average n-Gain of students' creative thinking skills has moderate criteria.

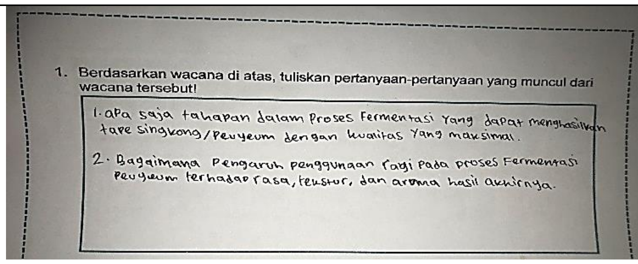
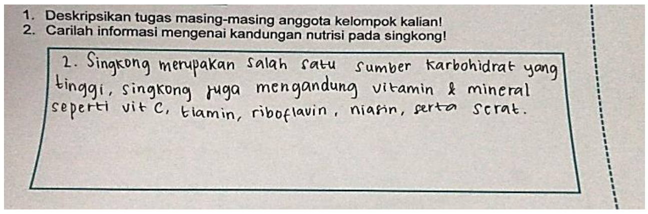
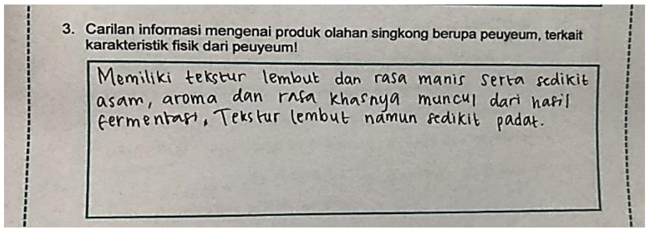
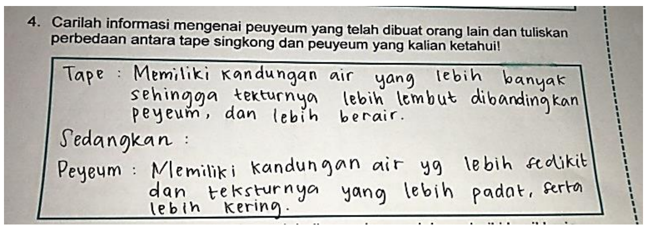
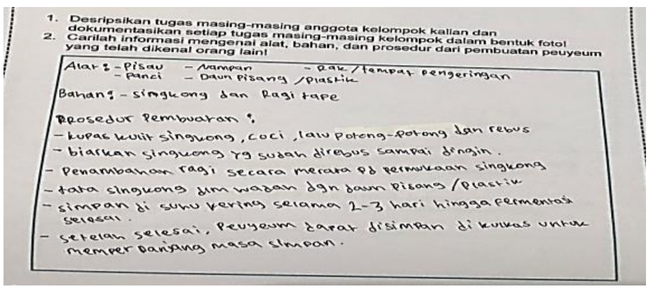
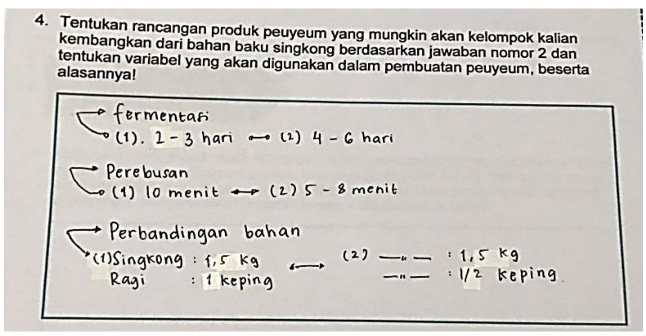
Learning with the STEM-PjBL model makes students creative (Widyasmah et al., 2020) and develops their critical thinking skills in solving the problems they face (Iskandar et al., 2022). Strategies to improve creative thinking skills include using a science scenario-based approach because it is easier to start because it is not too limited by rigid content in the syllabus. The science scenario-based approach requires students to analyze ideas and decide on creative solutions to open-ended problems in assignments (Cheng, 2010). Natsir et al. (2022) added that students can conduct discussion sessions between group members, carry out teamwork tasks, research-based work, utilize technology, student-centered methods such as discussing, expressing arguments, and problem-solving activities related to everyday life phenomena.

The results of data analysis using paired sample t-test obtained sig. (2-tailed) 0.000 with the H_1 acceptance test criteria which means there is a significant difference between the pretest and posttest scores, with the average posttest score (72.99) higher than the pretest score (41.85). Learning using worksheets based on PjBL-STEM enables students to generate ideas to make complete and neat reports and train creative thinking skills (Afrijhon et al., 2022). This is because applied learning is contextual by integrating aspects of science, technology, engineering, and mathematics with various group project activities so that students are more active in the learning process and meaningful (Kurniahtunnisa et al., 2023). The STEM-PjBL-based learning environment improves students' 4C skills (Triana et al., 2020). In addition, this STEM-PjBL learning can support students' creativity in learning to create a product that generates creativity in solving a problem (Karlina et al., 2023). According to Diaz et al. (2007), students through STEM-PjBL syntax have the opportunity to model solutions, practice solving problems, and receive constructive feedback on high-level tasks from peers and teachers. STEM-PjBL-based learning can help students connect the knowledge gained with its application in real life. The integration of science, technology, engineering, and mathematics (STEM) helps students understand that there is a relationship between fields of science (Hanif et al., 2019).

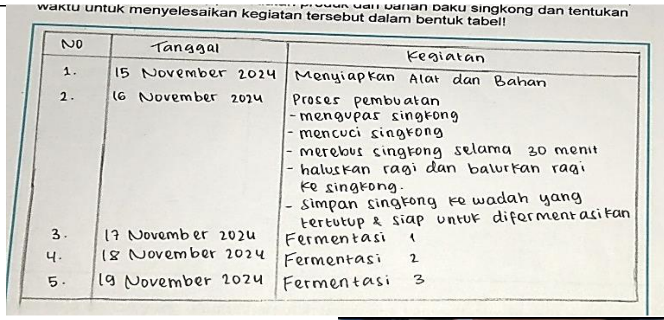
The improvement of students' creative thinking skills can be observed from the results of students' work in STEM-PjBL-based worksheets. In the first stage of the STEM-PjBL syntax Laboy-Rush (2011), learning carried out using STEM-PjBL-based worksheets is able to make students more aware of their understandings obtained through the discourse given at the reflection stage. After gaining understanding through discourse, the process of realizing the understanding that can be developed by the students is research syntax. In addition to exploring information to solve problems, students in this syntax develop from concrete understanding to abstract understanding of the problem. Furthermore, discovery syntax, students at this stage compile projects. In addition, this syntax is also able to develop students' abilities to reflect on "thinking habits". Then after determining the product as an alternative solution to the problem, the implementation of product creation is carried out at the application stage which will then be evaluated and presented at the communication stage. At the application stage, students make *peuyeum* products according to the predetermined variables. During the product making, students can evaluate the ideas obtained so that students will get conclusions to improve the idea and there are no shortcomings (Sukmawijaya et al., 2019). Through the STEM-PjBL syntax in the worksheets which in each question item has trained indicators of creative thinking skills, students' creative thinking skills can increase (Widyasmah et al., 2020). Students' answers in the worksheets for making *peuyeum* products are shown in Table 8.

Based on the trial process with various different independent variables in each group, several processed *peuyeum* products were obtained. The assessment aspects in making *peuyeum* products include the product manufacturing process (preparation of tools and materials, steaming cassava, adding yeast, and fermentation process), and product quality (physical form and color of the product). Products are grouped into low criteria if they have a soft texture and white and brownish color, while high criteria products have a slightly wet texture that tends to be dry and a yellowish white peuyeum color. The results of *peuyeum* processing are shown in Figures 3a and 3b with the final results of the product assessment sequentially with the criteria "low" and "very high". In Figure 3a, the "low" product assessment criteria are obtained, the peuyeum results are obtained with product quality seen from its texture and color. The texture obtained is soft and does not leave marks with the peuyeum color tending to be brownish. While in Figure 3b, the "very high" product assessment criteria are obtained, the product quality is found with a slightly wet texture that tends to be dry, leaving marks, with a yellowish white *peuyeum* color. Low criteria products occur because the process of giving yeast and cassava used is 3.5 grams and the fermentation time is 2 days. High criteria products are obtained because the yeast component used in this peuyeum is 5.25 grams and the fermentation time is 2 days.

Table 8. Student Answers in the Worksheets for Making *Peuyeum*

Syntax	Student Answers	Trained indicators
Reflection	 1. Berdasarkan wacana di atas, tuliskan pertanyaan-pertanyaan yang muncul dari wacana tersebut! 1. apa saja tahapan dalam proses fermentasi yang dapat menghasilkan tape singkong/peuyeum dengan kualitas yang maksimal. 2. Bagaimana pengaruh penggunaan ragi pada proses fermentasi peuyeum terhadap rasa, tekstur, dan aroma hasil akhirnya.	Fluency and originality
Research	 1. Deskripsikan tugas masing-masing anggota kelompok kalian! 2. Carilah informasi mengenai kandungan nutrisi pada singkong! 2. Singkong merupakan salah satu sumber karbohidrat yang tinggi, singkong juga mengandung vitamin & mineral seperti vit C, tiamin, riboflavin, niasin, serta serat.	Fluency and originality
	 3. Carilan informasi mengenai produk olahan singkong berupa peuyeum, terkait karakteristik fisik dari peuyeum! Memiliki tekstur lembut dan rasa manis serta sedikit asam, aroma dan rasa khasnya muncul dari hasil fermentasi. Tekstur lembut namun sedikit padat.	
	 4. Carilah informasi mengenai peuyeum yang telah dibuat orang lain dan tuliskan perbedaan antara tape singkong dan peuyeum yang kalian ketahui! Tape : Memiliki kandungan air yang lebih banyak sehingga tekturnya lebih lembut dibandingkan peyeum, dan lebih berair. Sedangkan : Peyeum : Memiliki kandungan air yg lebih sedikit dan teksturnya yang lebih padat, serta lebih kering.	
Discovery	 1. Desripsikan tugas masing-masing anggota kelompok kalian dan dokumentasikan setiap tugas masing-masing kelompok dalam bentuk foto! 2. Carilah informasi mengenai alat, bahan, dan prosedur dari pembuatan peuyeum yang telah dikenal orang lain! Alat : - Pisau - Nampan - Rak / tempat pengeringan - Panci - Daun pisang / plastik Bahan : - singkong dan Ragi tape Prosedur Pembuatan : - kupas kulit singkong, cuci, lalu potong-potong dan rebus - biarkan singkong yg sudah direbus sampai dingin. - Penambahan ragi secara merata pd permukaan singkong - tata singkong dim wadah dgn daun pisang / plastik - simpan di suhu kering selama 2-3 hari hingga fermentasi selesai. - setelah selesai, peuyeum dapat disimpan di kulkas untuk memperpanjang masa simpan.	Flexibelity and originality
	 4. Tentukan rancangan produk peuyeum yang mungkin akan kelompok kalian kembangkan dari bahan baku singkong berdasarkan jawaban nomor 2 dan tentukan variabel yang akan digunakan dalam pembuatan peuyeum, beserta alasannya! fermentasi (1). 2 - 3 hari ↔ (2) 4 - 6 hari Perebusan (1) 10 menit ↔ (2) 5 - 8 menit Perbandingan bahan (1) Singkong : 1,5 kg ↔ (2) —"— : 1,5 kg Ragi : 1 keping —"— : 1/2 keping	

Syntax	Student Answers	Trained indicators
Application	(see below)	Elaboration


waktu untuk menyelesaikan kegiatan tersebut dalam bentuk tabel!

NO	Tanggal	Kegiatan
1.	15 November 2024	Menyiapkan Alat dan Bahan
2.	16 November 2024	Proses pembuatan - mengupas singkong - mencuci singkong - merebus singkong selama 30 menit - haluskan ragi dan balurkan ragi ke singkong. - simpan singkong ke wadah yang tertutup & siap untuk difermentasikan
3.	17 November 2024	Fermentasi 1
4.	18 November 2024	Fermentasi 2
5.	19 November 2024	Fermentasi 3

Based on the learning activities that have been carried out, the indicators of creative thinking skills that often appear at each stage of learning are fluency indicators. These results indicate that students have been able to find answer ideas or think of more than one answer to solve problems (Qomariyah & Subekti, 2021), where the various responses or solutions expressed determine the fluency of students. According to Cheng (2010) one approach that can improve creative thinking skills is a science process-based approach, through this approach one of the student's activities is to propose a new hypothesis, this method involves students in an open discovery process and scientific investigation that helps in developing new ideas. The indication of the fluency indicator in this study is when students write questions based on discourse and look for information related to nutrition in cassava. This is in line with Permana et al. (2023) which states that if students have the ability to present different ideas, and explain their ideas, then these students can be categorized as students who have creative thinking skills. Meanwhile, the indicator of creative thinking skills that rarely appears at each stage of learning is the elaboration indicator. Elaboration is an activity of adding or detailing an idea so that it can improve the quality of the idea (Torrance, 1974). The elaboration indicator has a lower average percentage compared to other indicators, although both have a high category percentage. This shows that students have a little difficulty in explaining an idea or describing in detail the experiment of making peuyeum products. Furthermore, Permana et al. (2023) explained that students are not used to thinking divergently or differently about a problem. In the activities in the Student Worksheet, students already know well the problem of differences in texture, taste, and color of peuyeum, but this has not been able to significantly increase the elaboration indicator. This is because students still have difficulty in evaluating the relationship between variables that cause differences in taste, texture, and color of peuyeum based on the specified variables. So that students have not been able to explain in detail the reasons and relationships between variables that can cause the taste of the resulting peuyeum to have a slightly wet texture that tends to be dry, trailing, with a yellowish white peuyeum color, and the right level of sweetness. Students are still accustomed to thinking convergently or solving problems in one way. This shows that they still lack the ability to produce or add more comprehensive details or justifications for the ideas they convey, and this is still far from the level of explanation needed. Increasing student elaboration can be done by creating thinking steps through building initial concepts, detailing the thinking framework, and identifying the concrete steps needed to develop ideas (Yasa et al., 2023; Priawasana et al., 2020).

Based on the STEM-PjBL learning that has been carried out, students have been able to answer pretest-posttest questions related to Biology subjects, and have a creative thinking skill level at level 4 (very creative). Because the fluency indicator often appears in the worksheets in the form of literature study activities for solving problems in everyday life and writing questions based on phenomena, the worksheets resulting from the development makes students able to answer pretest-posttest questions. The student fluency indicator is shown when students answer questions on the worksheets reflection syntax and research syntax. Unlike fluency, elaboration indicators rarely appear in every STEM-PjBL syntax. Elaboration indicators appear only at the application stage. The activities carried out by students at this stage are conducting experiments on making *peuyeum* and compiling reports on making *peuyeum*. Because it only appears once in this syntax, the student elaboration indicator has a percentage that is not as large as the other indicators, namely fluency, flexibility, and originality.

Figure 3. (a) *Peuyeum* criteria low; (b) *Peuyeum* B criteria very high

Table 9. Results of student responses to learning

Question	Percentage (%)	Criteria
The way of learning using the Project Based Learning (PjBL) model is very fun and makes learning more interesting.	91.40	Very high
The way of learning using the Project Based Learning (PjBL) model can improve my creative thinking skills.	90.62	Very high
I understand the material given by the teacher better by using the Project Based Learning (PjBL) model.	84.37	Very high
The way of learning using the Project Based Learning (PjBL) model can motivate me to be more active in learning.	87.50	Very high
Learning with the Project Based Learning (PjBL) model can help me find many new experiences.	87.50	Very high
Learning with the Project Based Learning (PjBL) model with discussion activities can increase my interest in learning.	86.71	Very high
I am motivated to seek information from various sources (books, articles, internet, etc.) that are needed in discussion activities.	88.28	Very high
The opportunity to discuss learning activities using the Project-Based Learning (PjBL) model made me braver in expressing my opinions.	85.15	Very high
The Project Based Learning (PjBL) model worksheets encourages me to produce a product with realistic value.	84.37	Very high
The Project Based Learning (PjBL) model worksheets motivates me to further emphasize my creative thinking skills in carrying out a project.	85.15	Very high
worksheets Project Based Learning (PjBL) model helps me in planning a project (starting from designing the product to designing the experimental procedure).	85.93	Very high
worksheets Project Based Learning (PjBL) model is easy to understand	89.06	Very high
With the Project Based Learning (PjBL) model, I can appreciate other people's opinions more.	83.59	Very high
The way of learning with the Project-Based Learning (PjBL) model makes me brave to show new ideas and concepts to teachers and friends.	86.71	Very high
The way of learning with the Project Based Learning (PjBL) model can foster a sense of critical thinking, creativity, scientific thinking, and cooperation in groups.	89.84	Very high
Average	84.81	Very high

The final stage of the embedded experimental model is qual after intervention. Data sources at this stage include student responses to the learning program using STEM-PjBL-based worksheets for making *peuyeum* to improve creative thinking skills. After conducting the experiment of making *peuyeum* products, students were given a questionnaire in the form of responses to the learning that had been carried out. The results of student responses to the learning carried out are presented in Table 9. Student responses to learning using STEM-PjBL-based worksheets for making *peuyeum* were obtained on average with the criteria of "very high". This means that students feel happy and interested in learning using the STEM-PjBL model. STEM-PjBL-based science learning makes students not only learn about scientific concepts, but also learn to work together effectively, share ideas, solve real problems, and design creative solutions together (Triprani et al., 2023). Combining Science, Technology, Engineering, and Mathematics, STEM-PjBL learning provides a holistic framework for students to understand how various concepts are interconnected and can be applied to solve contextual problems (Martatiyana et al., 2024). Through a series of activities such as observation, experiments, and field visits, students can learn independently, understand subject matter easily, have a positive attitude towards science, and develop their creative thinking skills (Handayani et al., 2021).

Conclusion

Learning using STEM-PjBL-based workheets to make peuyeum provides an opportunity for students to further explore knowledge related to the use of living things/microorganisms in the context of biotechnology. The product of the development of STEM-PjBL-based workheets for making peuyeum was declared valid through expert validation to improve students' creative thinking skills based on the results of expert validation which stated that the developed workheets had met the aspects of material suitability (89.77%), construction (90.62%), and readability (87.50%), and the results of teacher responses to the developed workheets obtained an average percentage of material suitability aspects (93.18%) and readability (91.66%) with very high criteria. Based on this, the developed workheets which were valid and feasible to use were then tested in class to determine their effectiveness in improving creative thinking skills. The results of the paired sample t-test stated that there was a significant difference between the pretest (41.85) and posttest (72.99) scores of students, so that the STEM-PjBL-based peuyeum making workheets that was developed was effective in improving creative thinking skills. This is reinforced by the positive response of students as seen from the results of the output of student responses to STEM-PjBL-based workheets learning in learning to make peuyeum with an average percentage (84.81%) with very high criteria.

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S. T. M. contributed to collecting data, analyzing data, and writing the draft article. N. F. and K. H. guided the implementation of research, writing articles, providing input on draft articles, and reviewing articles.

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