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The framework of project-based learning (PJBL) activities with steam approach in enhancing creative thinking skills in solving data presentation problems based on etnomathematics

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Abstract
Creative thinking skills play a crucial role in the 21st-century transformation era. Creative thinking skills influence the ability to generate ideas, discover connections, stimulate imagination, and have various perspectives. Creative thinking skills can be improved by applying Project Based Learning (PjBL) integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. The STEM-based learning method applies knowledge and skills simultaneously to solve a case. This approach is a 21st-century learning approach to produce human resources with quality cognitive, psychomotor, and affective abilities. Students' creative thinking skills must be improved because the learning models used so far are still lacking in integration with STEM and related to ethnomathematics-based learning. Therefore, this study is about improving creative thinking skills through the application of Project Based Learning (PjBL) integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach based on ethnomathematics by presenting local wisdom-themed problems that stimulate students' learning spirit in formulating solutions through the presentation of data using recycled materials.

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Keywords: PjBL, STEAM, Creative Thinking Skills, Ethnomathematics

1. Introduction

21st-century skills are seen as essential skills that students need to develop to enhance their life skills, and soft skills as the main asset to face the challenges of complex and uncertain life caused by dynamic changes in the world. As one of the 21st-century skills, creative thinking skills are important for students [7]. States that creative thinking skills play a role in developing individuals' problem-solving abilities and improving their understanding. According to [15], creative thinking skills aim to synthesize ideas, generate new ideas, and determine the effectiveness of existing ideas. The development of students' creativity can be achieved through activities such as observation, experimentation, and field trips, which enable students to learn independently for better understanding.

The improvement of creative thinking skills can be achieved by implementing the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach in learning. According to [5], an integrated STEM approach to learning is highly effective in achieving learning objectives and can improve education quality more rapidly than traditional methods. This view is supported by [4], who states that the STEAM approach to learning can be used as a means for students to generate ideas by integrating the five disciplines through creative problem-solving and exploration. The exploration carried out by students in STEAM learning can be manifested in project activities that promote creativity and collaboration among students. Therefore, implementing the STEAM approach in education can also be combined with the Project Based Learning (PjBL) model as they share similar characteristics.

According to [1], the PjBL model emphasizes the modeling of a project to produce an output in the form of a product. Learning involves activities that share project experiences to generate effects from students' activities. This is supported by [6], who states that the advantages of PjBL are that it can provide motivation and knowledge to students, enabling them to create original problem-solving solutions to real-world problems and work collaboratively with other students to formulate creative solutions that are valuable and meaningful tasks, thus developing their knowledge and social skills as part of their learning experience.

Implementing PjBL (Project-based Learning) as one of the systematic learning approaches engages learners through real-world problem contexts and enhances life skills through creative, scientific, authentic, and challenging processes that result in products [13, 14]. The real-world problem context allows PjBL to be integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. One element of STEAM closely related to learners' real life is culture and mathematics, known as ethnomathematics in this study, which involves a collection of Indonesian cultural artifacts stored in the Gubug Wayang Museum. Therefore, the initial problem addressed in this research is presenting data from the collection of the Gubug Wayang Museum, which will be combined with the utilization of recycled materials.

The reference sources used include a study entitled "Implementation of Project-Based Learning Model (PjBL) Using STEAM-Based Approach in Elementary Schools" [2], which successfully demonstrated an increase in student activities and improvement in the creation of students' innovative products. Another study was conducted by [8] on the effect of the Project-Based Learning (PjBL) Model based on ethnomathematics on students' creative thinking skills. The conclusion was that student activities in learning showed better experimental class activity than the control class and significantly affected students' creative thinking skills.

According to [16], creative thinking skills will improve if learners can think broadly and think about new ideas and solutions through activities such as asking unusual questions and designing unconventional answers. The indicators of creative thinking skills in this study used Silver's opinion [3], which refers to a) fluency, if learners can solve problems with various interpretations, solution methods, or problem answers; b) flexibility, if learners can solve problems in one way, and then by using another way, learners can discuss various solution methods and c) novelty through problem-solving, if learners can examine several solution methods or answers and then create a different solution method. All three indicators require the teacher's role as a facilitator in maximizing the achievement of these indicators in learning.

Efforts to maximize learning naturally require the availability of learning devices, including lesson plans, student worksheets, assessment sheets, and research instruments designed to improve students' creative thinking skills to support the learning process's success.

2. Research Method

This study is a research and development (R&D) study with descriptive qualitative analysis. The study began with a literature review of PjBL, STEAM, and ethnomathematics. The next step was to delve deeper and present the problem of PjBL-STEAM based on ethnomathematics as the basis for developing the research framework. The next stage was to create a syntax framework that integrates PjBL with STEAM-based ethnomathematics approaches in solving data presentation problems. The research continued by developing a teaching module that presents learning outcomes and objectives, including achievement indicators with research instruments. The next step was to conduct validation or feasibility testing by experts to determine the feasibility of the developed teaching module.

The study then proceeded to describe the role of the five elements of STEAM in solving ethnomathematics-based problems presented. The next step was to describe each stage of PjBL-STEAM in detail and order, in the form of learning activity presentations that were carried out, followed by completing the activity indicators and creative thinking skills with the help of research instruments. The final step was to describe the portrait of the creative thinking skills phase of the students in solving problems based on the research instrument that has been completed.

3. Result

Syntax of Integrating PjBL with STEAM Approach to Enhance Creative Thinking Skills in Solving Ethnomathematics-Based Data Presentation Problems

The syntax of PjBL learning integrated with the STEAM approach in enhancing creative thinking skills in solving data presentation problems based on ethnomathematics in this research was developed based on the syntax in [10] with the following elaboration:

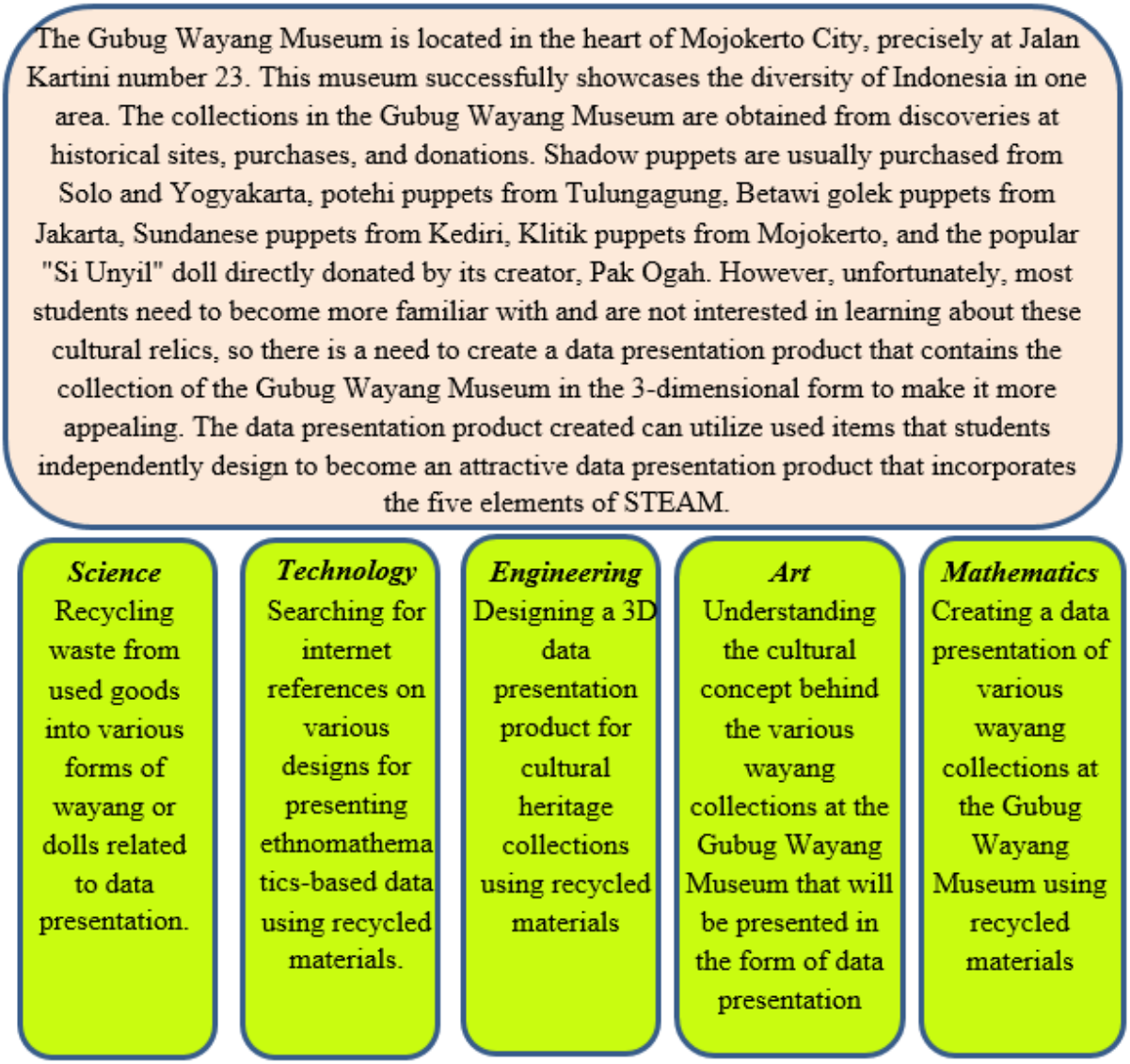

Fig 1: Problem-based learning (PjBL) with STEAM approach based on ethnomathematics

The framework of the PjBL model integrated with the STEAM approach in this study comprises several stages. The first stage is reflection, aiming to bring students into the problem's context and provide stimulus to start an investigation. In this stage, students are encouraged to link what they already know with what they need to learn next. The second stage is research, which is the phase where students carry out research activities, and most of the learning process occurs during this stage by accommodating students. At the same time, they collect relevant information for their learning progress to concretize their abstract understanding of a problem. The third stage is discovery, which generally involves bridging research and known information in the preparation of the project. When students start to learn independently and determine what is still unknown. The fourth stage is the application, to test the product or problem-solving solution produced.

In some cases, students test products made from previously established criteria, and the results obtained are used to improve the previous steps. The fifth stage is the final stage, communication, where students present the product or solution produced in the project to their classmates to develop communication and collaboration skills and the ability to receive feedback. The framework of the PjBL-STEAM integration in this study is presented in Figure 2 as follows.

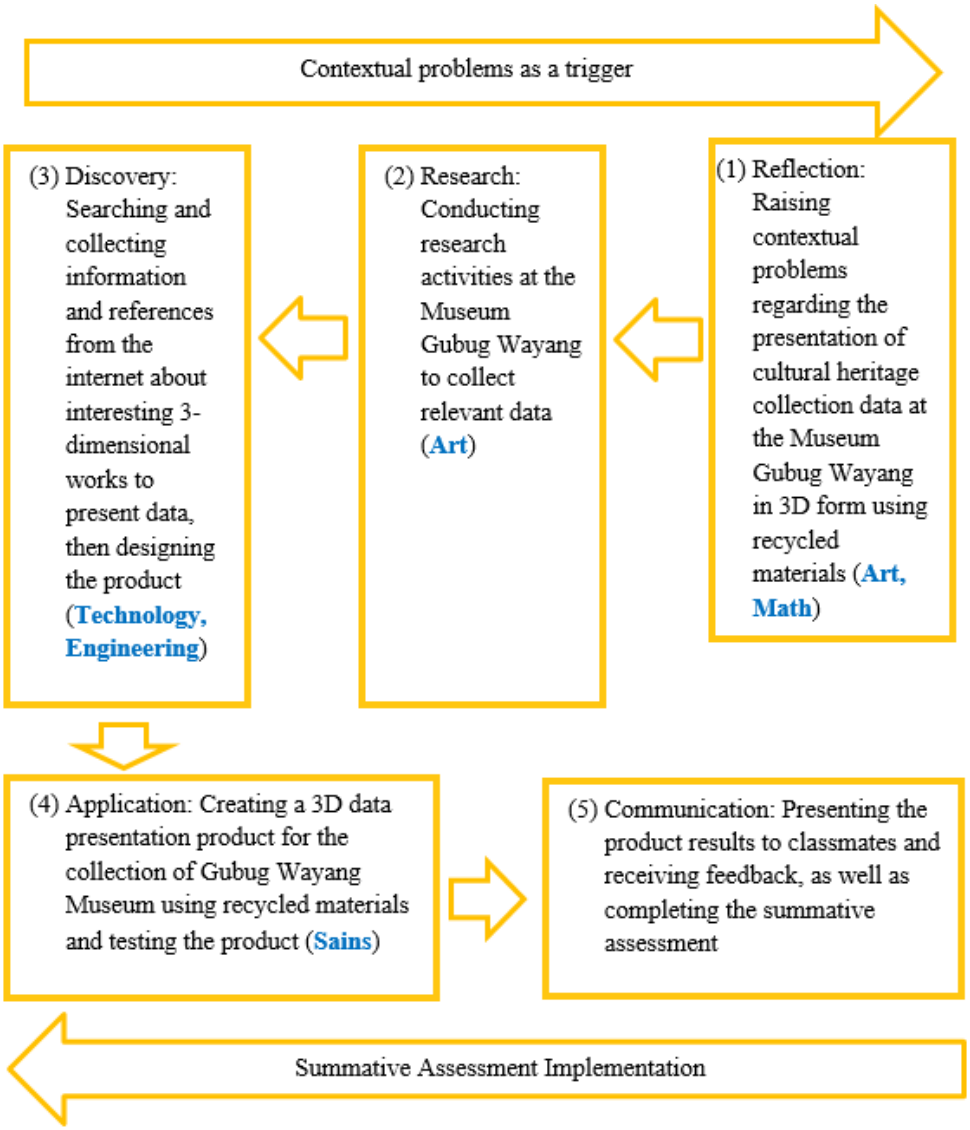

Fig 2: PjBL Framework Integrated with STEAM in Solving the Problem of Ethnomathematics-based Data Presentation

In the framework, students' creative thinking skills in solving problems are evaluated based on the data presentation product they create. They are supported by the results of the students' summative assessment. The summative assessment consists of 4 (four) open-ended questions, thus providing flexibility for students to demonstrate their creative thinking skills.

The Results and Learning Objectives of Students

The expected learning outcomes from this research process are that students can design and create a product for presenting cultural artifact data stored in the Gubug Wayang Museum in three dimensions, utilizing the available recycled materials around them. These learning outcomes indicate the development of students' creative thinking skills in problem-solving.

The learning objectives of PjBL integrated with the STEAM approach in this research are to solve problems related to presenting ethnomathematical data by developing students' knowledge and skills in the five fields of Science, Technology, Engineering, Arts, and Mathematics. Each element in the STEAM approach has its learning objectives, detailed as follows:

a. Science

After carrying out the research process, the students are expected to:

- Understand and sort used items according to their properties to form them into a 3-dimensional presentation data product.

b. Technology

After conducting the research process, the students can:

- Utilizing the web and YouTube as a source of digital literacy in developing a data presentation product that uses recycled materials.

Transforming waste into wayang puppets: https://www.youtube.com/watch?v=bOhPB-L6wT0&pp=ygUTd2F5YW5nIGJhcmFuZyBiZWthcw%3D%3D

How to make recycled cardboard into the trash: https://www.youtube.com/watch?v=vMyJjx8iVFU&pp=ygUTd2F5YW5nIGJhcmFuZyBiZWthcw%3D%3D

How to make wayang golek from recycled materials: https://www.youtube.com/watch?v=wPpuh2gLSm0&pp=ygUTd2F5YW5nIGJhcmFuZyBiZWthcw%3D%3D

- Utilizing Microsoft Excel application to calculate

summaries in tables or design diagrams.

c. Engineering

After conducting the research process, students are expected to be able to:

- Design a product for presenting data on the collection of cultural objects stored in the Gubug Wayang Museum in 3D form using recycled materials around the students.
- Create a product for presenting data on the collection of cultural objects stored in the Gubug Wayang Museum in 3D form using recycled materials around the students.

d. Arts

After conducting the research process, students are expected to:

- Understand and comprehend the collection of cultural objects stored in the Gubug Wayang Museum.

e. Mathematics

After conducting the research process, students can:

- Collect 3D data of cultural objects stored in the Gubug Wayang Museum using recycled materials available around them.
- Present the 3D data of cultural objects stored in the Gubug Wayang Museum using recycled materials available around them.

Elements of Developing PjBL Teaching Modules Integrated with STEAM Approach in Solving Ethnomathematics-based Data Presentation Problems

a. Science Elements

Used items can be one of the materials used in the recycling process, which can produce reusable products. To carry out recycling, it is necessary to sort the waste based on its type and the characteristics of its constituent materials so that it can facilitate the processing process.

The properties of materials that need to be considered by students in sorting used items to be recycled into products in this research are as follows:

- Plastic has lightweight, non-absorbent, strong, and durable properties.
- The fabric has heat-resistant, flexible, strong, and absorbent properties.
- The paper has a foldable, easy-to-cut, absorbent, and flammable property.
- The thread has a flexible property, making it easy to make knots, and has good strength, making it less prone to breakage.

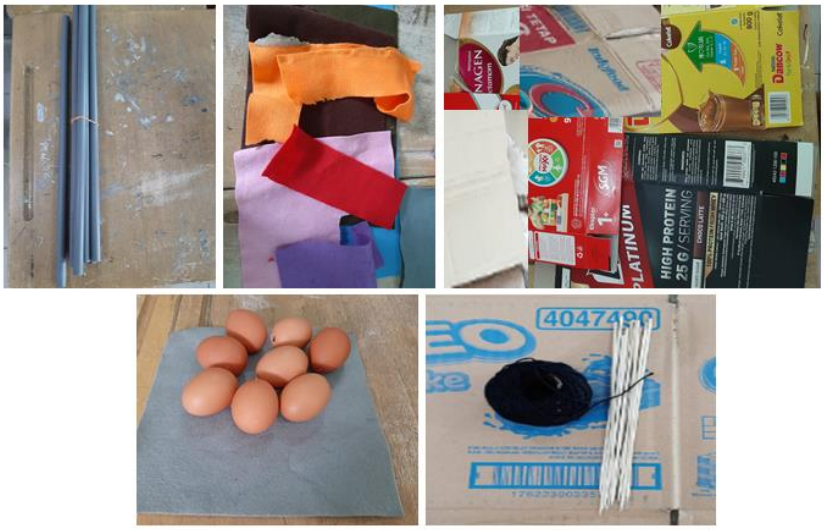

Fig 3: Used items used in making the product

b. Technology Elements

Efforts to solve the problem of creating a product that can increase students' knowledge and understanding of the culture around them and enhance their creative thinking skills by utilizing used items around them can be made by conducting literacy research with the help of technology. This is currently easy to do, given that internet technology provides abundant literacy resources. The proper use of internet technology will help develop new knowledge and facilitate understanding for students.

In this study, the technology usage element is divided into two, namely the use of applicative energy in the form of formulas and the creation of diagrams with Microsoft Excel, as well as the use of search facilities through the web or YouTube.

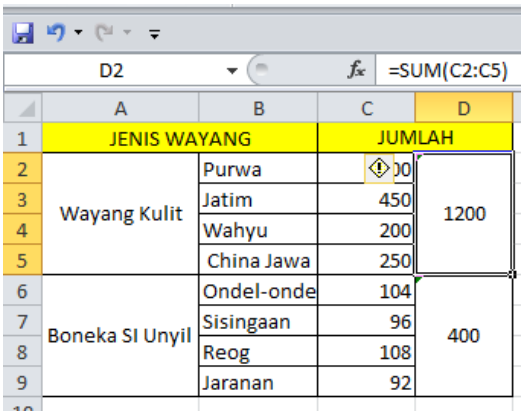

Fig 4: Applied technology of formula summary in Microsoft Excel

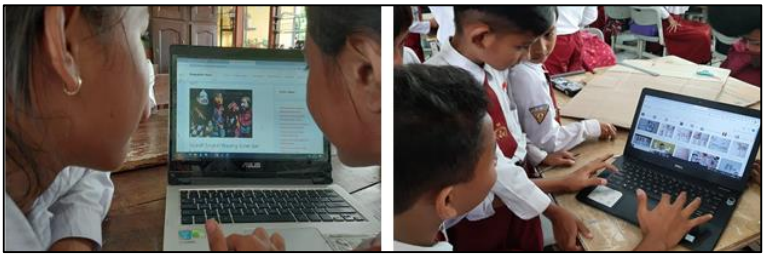

Fig 5: Utilization of search facilities using the Web and YouTube

c. Engineering Elements

The engineering element in this study is divided into two activities. The first activity is to design a product to present the collected data of cultural objects stored in the Gubug Wayang Museum in 3D form using used items. The stages of making the product design that students will create are as follows:

1. Students determine the data that will be presented, including the collection of cultural objects in general or discussing only one type of collection divided into several categories.
2. Students determine the design of the 3D data presentation that will be created, as shown in the following picture:

Fig 6: Example sketch of a wayang design from used items

The second activity in the engineering element of this study is to create a product for presenting the collection data of cultural objects stored in the Gubug Wayang Museum in 3D form by utilizing used items around the students. The stages of making the product for presenting the data that the students will create are as follows:

1. Prepare the tools and materials that will be used to make the 3D product for presenting the collection data.
2. Create the 3D product for presenting the collection data of cultural objects stored in the Gubug Wayang Museum by utilizing used items around the students.

Fig 7: Making a wayang product from used items

3. Test the product

d. Arts elements

The art elements in this study include the product resulting from presenting the collection data of cultural objects stored in the Gubug Wayang Museum, as shown in the following picture:

Fig 8: Example of a wayang product made from used items

e. Mathematics elements

The mathematics elements in this study are in the form of presenting data which includes data collection, reading and interpreting data, and presenting data. Data presented in this study is done by modifying and creating a presentation of previously learned data.

Fig 9: Example of data presentation of the Gubug Wayang Museum collection

Integrated STEAM PjBL Learning Framework in Solving Ethnomathematics-based Data Presentation Problems

There are five stages in the integrated STEAM PjBL learning framework [9] in this research, as described in Figure 2 of the PjBL integrated STEAM framework in solving ethnomathematics-based data presentation problems to improve creative thinking skills, as follows:

a. The first stage is reflection, which is carried out by providing a basic ethnomathematics-based problem context. The activity then continues by stimulating the students to start the investigation and encouraging them to link what they already know with what needs to be learned. The first stage activity is described in detail in Table 1

Table 1: Learning Activities of PjBL-STEAM in the first stage

Stage 1	Learning Activities	
Reflection	1	Students watch a video about Indonesian cultural heritage. (**Arts**)
	2	Students pay attention to the problems presented by the teacher on the projector screen.
	3	Students read and reflect on the problems one by one.
	4	Through a brainstorming activity, students can design general steps to solve the problems.

b. The second stage is research, which is carried out through activities such as collecting relevant information by conducting direct research to concretize the abstract understanding of a given problem. In this second stage, students begin to work in groups.

Table 2: PjBL-STEAM Learning Activities in Stage 2

Stage 2	Learning Activity	
Research	1	Students are divided into six groups.
	2	Students conduct research at the Gubug Wayang Museum to gather relevant information.
	3	The teacher provides Student Worksheet 1 (SW1) as a guide for gathering relevant information related to the collection of cultural objects at the Gubug Wayang Museum in Mojokerto City. (**Mathematics**).
	4	Students write their research findings in SW1.
	5	The teacher observes the results of each group's work and provides guidance and feedback on the completeness and clarity of each group's information gathering.

Fig 10: Research Visit to Gubug Wayang Museum

c. The third stage is discovery, carried out through various activities that can bridge research and information in preparing a project. In this stage, students determine the project idea they will create and then continue by finding literacy sources that support the smoothness of the product creation project. This stage is completed by creating a product design that students will develop to solve the problem.

Table 3: PjBL-STEAM Learning Activities in the Third Stage

Stage 3	Learning Activity	
Discovery	1	The students collaborate in groups to gather information from online media or reference books in the library related to 3-dimensional data presentation forms using recycled materials (**Technology**).
	2	The teacher distributes Student Worksheet 2 (SW 2) to include the design of the data presentation to be created.
	3	The students work in groups to design the data presentation and write it down in SW 2 (**Engineering**).
	4	The teacher walks around to observe the designs made by each group and provides necessary guidance and feedback on the product design to be used by the group in problem-solving.
	5	The students plan and select the recycled materials to be used in the presentation, adjusting the characteristics of the material according to the design created (Science).

Fig 11: Creating a design in a group/team

d. The fourth stage is the application, which is carried out through trial activities on the product or problem-solving solution produced. During the trial, learners test the product based on predetermined criteria, and the results obtained are used to improve the previous steps.

Table 4: PjBL-STEAM Learning Activities in the Fourth Stage

Stage 4	Learning Activity	
Application	1	Learners work together in groups to create a data presentation product containing information on the collection of cultural objects in the Gubug Wayang Museum in Mojokerto City, according to the design that has been created.
	2	Learners test the data presentation product that has been produced.

Fig 12: Creating a data presentation product

e. The fifth and final stage is communication, marked by a window shopping activity to showcase the product produced in the project by learners to their classmates. In this stage, learners can also provide feedback and reinforcement to the products of other group works.

Table 5: PjBL-STEAM Learning Activities in the fifth stage

Stage 5	Learning Activity	
Communi-cation	1	The problem-solving product that has been tested is then displayed on the table provided for each group.
	2	Each group agrees on the preparation of window shopping (determining one seller and buyer of information).
	3	The teacher distributes post-it notes to each learner.
	4	Peserta didik melakukan kegiatan *windows shopping*.
	5	Learners engage in window shopping activities. Each group is given 3 minutes to analyze the strengths and weaknesses of the problem-solving product in each group and provide comments using post-it notes. The teacher instructs to shift the visiting group.
	6	Each group then gathers to review the feedback from other groups.
	7	Each group responds to the feedback received.
	8	The teacher asks each group to take turns giving awards (star icons) to one group with the most creative results according to their group.
	9	One group with the highest number of stars presents their group's work.
	10	Learners are allowed to provide feedback or questions to the presenting group.
	11	Learners pay attention to the teacher's reinforcement of the learning material.
	12	With the teacher's help, learners write a conclusion to the learning material.

Fig 11: Windows shopping and presentations

Framework of Teaching Module Feasibility Instrument in Enhancing Creative Thinking Skills

An assessment instrument is one form of confirmation of learning outcomes, especially in describing the process and achievement of student's creative thinking skills. The assessment instrument for students' creative thinking skills is presented in the following Table 6:

Table 6: Framework for assessing creative thinking skills

Indicator	Sub-indicator		Test Material
fluency	a.	Generating many ideas, answers, and problem-solving strategies.	Proposing many questions.
	b.	Providing many ways or suggestions to do various things.	Providing multiple answers if there is a question.
	c.	Providing many ways or suggestions to do various things.	Having many ideas about a problem.
	d.	Always thinking of more than one answer.	Fluently expressing their ideas.
flexibility	a.	Generating varied ideas, answers, or solutions.	Providing various interpretations of a picture, story, or problem.
	b.	Able to see a problem from different perspectives.	Applying a concept or principle in different ways.
	c.	Seeking many different alternatives or directions.	Thinking of different ways to solve it.
originality	a.	Providing new ideas or solutions (novelty) in solving problems.	Questioning old ways and trying to think of new ways.
	b.	Able to create unusual combinations of parts or elements.	Thinking of problems or things that others have yet to think of.

Follow-up on the Development of Teaching Modules

The follow-up on the development of teaching modules in this study used the ADDIE development model, which consists of 5 stages, namely: (1) Analysis; (2) Design; (3) Development; (4) Implementation; and (5) Evaluation [12]. The selection of the ADDIE model was considered practical because it has sequential, simple, and easily applicable steps. The first stage of development is the analysis stage, which is carried out by analyzing the root of the problem, students' characteristics, concepts, tasks, and learning objectives. This analysis is important to ensure that the problem-solving product produced meets primary schools' needs and characteristics.

The second stage is the design stage, which aims to prepare the initial form or design of the PjBL teaching module with a STEAM approach based on ethnomathematics using recycled materials. At this stage, the designed teaching module consists of lesson plans, student worksheets, summative test sheets, observation sheets, and student response questionnaires.

The third stage is the development stage, which aims to produce the final form of the teaching module that has been revised based on experts' opinions. This third stage begins with testing the teaching module's validity, practicality, and effectiveness. Validation results include the format of the teaching module, learning activities, and language. The practicality of the teaching module is measured based on observation sheets of teacher and student activities and student response questionnaires. The effectiveness of the teaching module is measured based on an assessment instrument of creative thinking skills.

The fourth stage is implementing the PjBL teaching module with a STEAM approach to improve students' creative thinking skills in solving ethnomathematics-based data presentation problems. The final stage is the evaluation stage, which begins by implementing trial runs in other schools, then collecting response data and analyzing it to test the validity of the data as a basis for conclusions.

4. Discussion

Developing a framework for creating PjBL teaching modules with a STEAM approach to enhance creative problem-solving skills in presenting data based on ethnomathematics is essential and beneficial, especially in primary schools where such activities are not commonly practiced. In addition, developing such activities will foster students' scientific thinking and acting using their knowledge and holistic skills encompassing various fields of study.

This research involves two research activities that can be further developed, namely: (1) developing PjBL teaching modules with a STEAM approach using the ADDIE development model and (2) analyzing the implementation of PjBL teaching modules with a STEAM approach to enhance creative problem-solving skills in presenting data based on ethnomathematics. This is consistent with the research conducted by Ahmad *et al*. (2021), which has been shown to increasing creative thinking of students by learning organization with STEAM Education.

5. Conclusion

The results of this study have visualized the syntax of integrating PjBL with the STEAM approach, with the main outcome being a framework of learning activities according to the PjBL integrated STEAM teaching module in improving creative thinking skills in solving data presentation problems based on ethnomathematics, which is

described in 5 stages of learning activities. In addition, the results of the study also include the development of assessment instruments related to creative thinking skills. Based on the process and results of this study, further research related to the development of teaching modules and analysis of PjBL implementation integrated with STEAM will be easier to conduct.

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