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The Development of PJBL-STEAM Learning Design to Improve the Student Creativity in Handling Waste: Utilizing Used Cardboard in Making Simple Miniature ATMs

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ABSTRACT: Students' creativity in handling waste is important to help them solve mathematical and SBdP concepts, especially operational problems such as building simple miniature ATMs and reusing waste. Therefore, this research is motivated to develop a learning design that increases students' creativity in handling waste, using the PJBL-STEAM approach as an effective method. The aim of this research is to increase students' creativity in handling waste. Phase portraits are given using PJBL-STEAM learning. This research uses a sequential exploratory mixed method design, which is characterized by qualitative data collection and data analysis first, and the next stage is quantitative data collection and second data analysis. The research subjects were 28 experimental elementary school students and 26 control students. According to research by Smith and Jones (2018), the project-based learning approach is effective in increasing student engagement and problem-solving skills. They emphasized the importance of combining this approach with aspects of STEAM (Science, Technology, Engineering, Arts, and Mathematics) to increase students' creativity in solving environmental problems, including waste management. The research method used in the research is the research and development method. This method will be used to develop and test the effectiveness of PJBL-STEAM learning designs that encourage student creativity in handling waste. The evaluation was carried out by observing student performance, evaluating simple miniature ATM products in the form of coins and paper made from used cardboard, and surveying student reactions to learning. The evaluation results will be used to measure the effectiveness of this learning design in increasing student creativity in waste management and recycling used cardboard. It is hoped that the development of the PJBL-STEAM learning design can help students improve their creative abilities in waste disposal and recycling used cardboard. It is hoped that the results of this research can become a reference for educators in the field of innovative learning which aims to develop 21st century skills.

KEYWORDS: Learning Design, Student Creativity, PJBL – STEAM, small ATM, Waste.

INTRODUCTION

Saving is a cultural value that is instilled in us from an early age. One of them, ``Be diligent if you are wise, thrifty if you are rich," still resonates with many people, especially children [1]. This can be seen from several slogans posted in schools, both kindergarten and elementary school. This slogan can motivate students, especially when it comes to saving. "It is important for parents to teach their children to save, especially to appreciate the value of money." We can teach students to save by giving them a piggy bank and money to put into the piggy bank later [22]. The amount of money to be deposited depends on whether it is banknotes or coins. There are several differences between old and modern piggy banks [3].

The 2021 UM Community Service Team implemented a community service program for elementary school children aged 9 to 12 years to make handicrafts from waste in the form of used cardboard [4]. PJBL-STEAM knows from this research that many traces were found scattered around, causing an unhealthy situation in the school environment [5]. This is because schools do not yet understand the benefits of managing used teaching materials in the form of used cardboard. Instead of using - which is scattered around the school environment, causing pollution which is not good for the environment, researchers took the initiative to use - to create something more useful for learning purposes at school [6]. In this case, researchers took the initiative to develop a mini media box that can be used as a medium to support student learning in class.

Researchers involve students in creating STEAM-based learning media [8]. Making a simple ATM in this research was carried out by collecting used cardboard, used paper and hot glue [9]. The waste is processed by paying attention to the size of each waste,

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and converted into mini boxes which can be used as learning media for coin boxes and mini banknotes to improve students' creative abilities [10]. These items can be thrown away at school and reduced little by little until they become useful items. In making props, cheap tools and materials are used and maximized to avoid high production costs and be able to process waste into more useful products [29]. The emphasis is on the use of used materials. To develop educational materials, several criteria must be met [13].

The Directorate of Secondary School Development (2011) stated that several criteria must be met, namely: materials that are easy to obtain (using waste and can be purchased at relatively cheap prices), easy to design, easy to manufacture, and easy to assemble. . And it is easy to use, can make concepts clearer or more expressive, can increase student motivation, is not dangerous and interesting to use, is very durable, innovative and creative, has educational value [16]. Make props using cheap tools and materials, and use as many used materials as possible, so that production costs are not too expensive, and waste can be processed into something more useful. Convertible goods. To carry out creative learning using used cardboard objects, researchers chose the PJBL-STEAM learning approach which is very effective in achieving learning goals and can improve the quality of education faster than before [2]. PJBL-STEAM integrates arts disciplines into the curriculum and learning areas of science, technology, engineering and mathematics [11].

PJBL-STEAM is a learning approach that emphasizes the relationship between knowledge and skills in the fields of science, technology, engineering, arts and mathematics to solve problems. If combined with 21st century skills (critical thinking, creativity, communication and collaboration), inquiry and problem solving, the PJBL-STEAM approach is very suitable for 21st century learning. The PJBL-STEAM approach is a learning approach that provides space for students to expand knowledge, science and humanities while developing 21st century skills such as critical thinking, communication, leadership, resilience and creativity [17]. PJBL STEAM-based learning requires students to identify problems and create something creative to solve them by collaborating and communicating effectively [18]. The problems identified are real life challenges that are close to students and contain challenges.

In this research, the use of used cardboard waste in the school environment was developed as learning material for mathematics and SBdP class 4 odd semester. The basic competencies developed are 3.4 (explaining cubes, rectangular prisms, prisms, pyramids, cylinders, cones and spheres and combinations of their shapes, as well as the surface area and volume of cubes and rectangular prisms) and 4.4 (recognizing cubes, rectangular prisms, prisms, pyramid, cylinder, cone, and sphere and combinations of their shapes, as well as the surface area and volume of cubes and rectangular prisms) [20]. This problem is related to waste in the environment around students, namely the presence of various student creativity in the form of miniature ATMs [23]. By using geometric concepts and creations that are familiar to students as learning resources, it is hoped that students can easily absorb and understand problems and improve their creative thinking abilities.

The ability to think creatively is one of the most important skills for facing the challenges of the 21st century. Creative thinking skills are better developed when students can think broadly about new ideas and solutions through the activity of asking unusual questions and designing unusual answers. With creative thinking skills, students will be better able to solve mathematics and SBdP problems, so it is important to carry out learning that focuses on developing students' creative thinking abilities [25]. Therefore, as formal educational institutions, schools and universities must organize learning activities that can develop students' creative thinking abilities. Students' creative thinking skills can be measured using "The Torrence Test of Creative Thinking (TTCT)."

Indicators of students' creative thinking abilities include fluency, flexibility, and novelty [26]. Fluency refers to producing different categories of ideas in response to a command. Flexibility refers to finding ideas from different perspectives and changing approaches in response to requests [27]. Novelty is the ability to generate new and unique ideas that are different from previous ideas and have not been considered by others. There is a lot of research on student creativity that has made a positive contribution to improving the quality of education, including efforts to improve students' creative thinking abilities. Likewise, research using the PJBL-STEAM approach shows promising results [28]. In this research, student creativity was focused on utilizing used cardboard by making simple miniature ATMs combined with the PJBL-STEAM approach.

The material used in this research is to increase students' creativity in handling waste: recycling used cardboard by making a simple miniature ATM. Students can make simple miniature ATMs from recycled cardboard waste available at school. The ATM miniatures can be animals, plants or houses with the characteristics of miniature ATMs which are dominated by terracotta colors (in this study, the natural color of cardboard is still used) and bank symbols [30]. This is also an effort to reduce waste in the school environment by processing it into useful and artistic objects. Learning materials are needed to improve creative thinking skills through fine arts-based mathematics learning and SBdP with the PJBL-STEAM approach to achieve this. The materials developed in

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mathematics and arts-based SBdP learning using the PJBL-STEAM approach include 1) curriculum; 2) learning plan; 3) student worksheets; and 4) grids and test sheets for creative thinking abilities in problem solving.

METHOD

This research uses a research and development (R&D) approach which involves iterative activities from model design to implementation with qualitative descriptive data analysis [7]. This research aims to develop arts-based mathematics and SBdP learning materials, using the STEAM approach, to improve creative thinking skills in solving problems related to 2D and 3D shapes. Specifically, the issue involves using recycled cardboard to build a miniature ATM that reflects the slogan "Cash Your Dreams, One Step at the ATM". Learning materials will be tested for suitability and further developed, including curriculum, lesson plans, worksheets, criteria and creative problem solving ability test sheets, as well as research instruments consisting of validation sheets, readability questionnaires, student response questionnaires to learning materials. processes, and criteria and test sheets for creative problem solving skills. This research began with a literature review related to mathematics and SBdP, miniature ATM, PJBL-STEAM, and creative thinking skills. The next step is to explore and explain mathematics and arts-based PPA-STEAM SBdP problems as a basis for forming a research framework. Then the role of the five PPA-STEAM elements in solving mathematical and fine arts problems based on ATM miniatures is explained. Followed by a complete and sequential description of each stage of the learning process in the form of a presentation of learning activities, equipped with activity indicators and creative thinking skills using research tools.

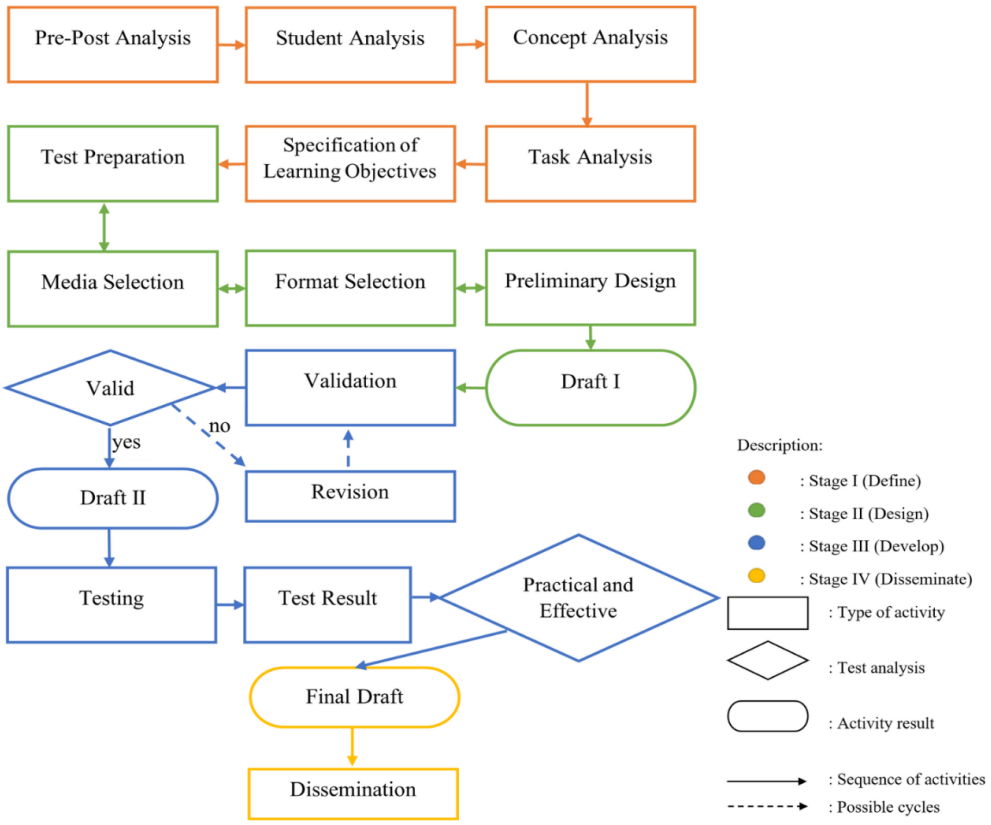

Figure 1. 4-D Model Design

RESEARCH FINDINGS

Syntax of Ethnomathematics Learning Based on Majapahit Culture with a STEAM Approach

The application of arts-based mathematics and SBdP learning in this research is integrated with the PJBL STEAM (Science, Technology, Engineering, Art, and Mathematics) approach. To improve creative thinking skills, the focus of this research is the use

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of cardboard to make art-based miniature ATMs (such as miniature animals, plants or buildings). The first step in problem solving to improve creative thinking skills is to understand the problem thoroughly.

The application of art-based math and SBdP learning in this study is integrated with the PJBL STEAM (Science, Technology, Engineering, Art, and Mathematics) approach. To enhance creative thinking skills, the focus of this research is the use of cardboard to create art-based ATM miniatures (such as miniature animals, plants, or buildings). The first step in problem solving to improve creative thinking skills is to thoroughly understand the problem.

Science	*Technology*	*Manipulation*	*Art*	*Mathematics*
Utilizing cardboard waste to make simple ATM miniatures that have fine art value resulting from student creativity is one of the efforts to preserve the environment.	Utilize the internet to search for information about miniature ATMs as a form of the slogan "Save Your Dreams, One Step at the ATM", determine the appropriate layout, and design and build a simple miniature ATM from used cardboard.	Design a simple ATM miniature sketch as a simple embodiment of the slogan "Your Dream Savings, One Step at the ATM". Determine the tools, materials and manufacturing process to realize the slogan "Your Dream Tube, One Step at ATM.	Understand the concept of the motto of the spirit of saving as student creativity and apply it in the work created.	Determination of measurements related to the surface area of a flat shape on a miniature ATM as a manifestation of the slogan "Your Dream Tube, One Step at the ATM".

Figure 2. Aspects of STEM research

The following framework table shows the correlation between the elements of saving-based math and SBdP learning and the PJBL-STEAM approach to improving creative thinking skills in problem solving in this study.

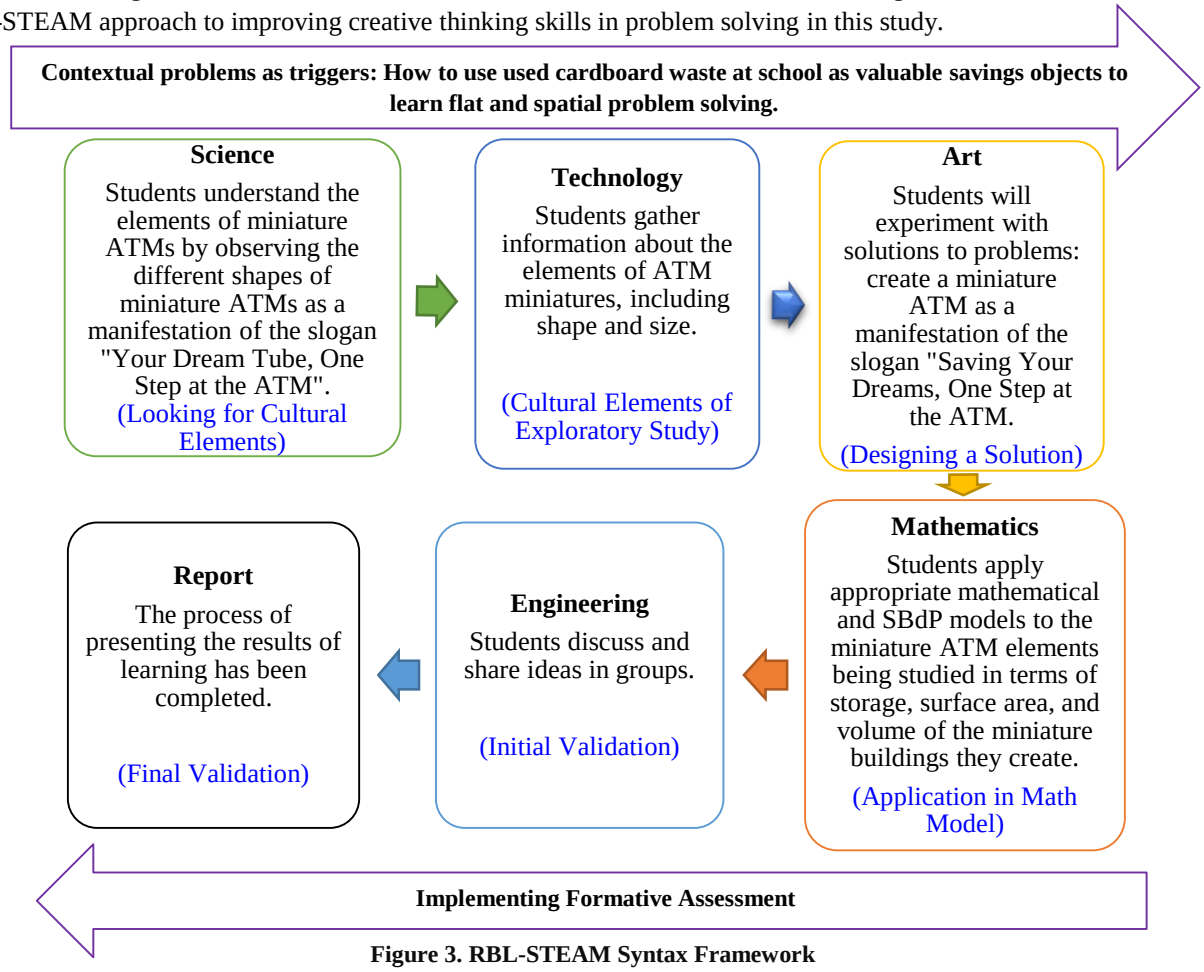

Figure 3. RBL-STEAM Syntax Framework

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Student Learning Goals and Objectives

Learning objectives provide direction in learning. This stage is the first step in creating a miniature RPP for mathematics and science based on ATM using the PJBL-STEAM approach. The learning objectives to be achieved are:

a. By using pictures or direct observation, students can identify flat shapes on miniature ATMs related to the theme of recycling plastic crafts;
b. By looking at pictures or directly observing and digging for information, students can identify the characteristics of flat buildings on miniature ATMs according to the theme "Your Dream Tube, One Step at the ATM";
c. Through discussion activities, students can find the length, width, and area of square and rectangular spaces;
d. By exploring the information, students are able to create a simple piece of art that is in line with the slogan "Your Dream Tube, One Step at the ATM".

The expected learning outcome from this lesson is that students can design and make miniature ATMs using used cardboard waste available in the school warehouse or at home. These learning outcomes show the development of students' creative thinking abilities in solving two-dimensional problems. The aim of arts-based mathematics and SBdP learning with the PJBL-STEAM approach is to develop knowledge and skills in various disciplines including science, technology, engineering, arts and mathematics:

a. In the science aspect, students are expected to Turn used cardboard into useful objects. Reuse used cardboard to help protect the environment.
b. For the technology aspect, students are expected to use the internet to find information about miniature ATMs as a manifestation of the slogan "Your Dream Tube, One Step at the ATM.
   Literature source: https://www.youtube.com/watch?v=PKDyqHn_e2Y
   Waste Recycling Creativity: https://www.youtube.com/watch?v=t4zmpIhBEGI
   https://www.youtube.com/watch?v=iIxm3yb8
   Use the Internet to find designs and techniques for making miniature ATMs out of cardboard. Reference source:
   https://www.youtube.com/watch?v=kNtuEdM2u_Q
c. In Engineering, students are expected to: 1) Create a miniature ATM design from used cardboard that includes flat and three-dimensional shapes. 2) Determine the tools and materials needed to make a miniature ATM out of used cardboard.
d. In art, students are expected to make a miniature ATM out of used cardboard to realize the slogan "Save Your Dreams, One Step at the ATM.
e. In mathematics, students are expected to find measurements of length, width, and area of flat shapes.

Development of Mathematics Learning and SBdP Elements of Fine Arts using the PJBL-STEAM Approach

a. Elements of a Science Problem

Garbage is waste material that is no longer utilized or reused after household or industrial processes. Trash must be thrown away, but waste management must be a priority to preserve the environment. Apart from markets, households, industry and offices, schools are one of the biggest contributors of waste. There are 3 (three) types of waste that are often found in schools, where these three types of waste are provided with bins in different colors. The three types of waste are organic waste, inorganic waste and B3 waste (B3 waste). Cardboard is a type of non-organic waste that has commercial value and is often sold to scavengers. However, cardboard waste can also be reused into useful items. Through the literacy resources provided, students can learn various ways to use used cardboard waste to protect the environment and create artistic value, such as miniature ATMs.

Figure 4. Preliminary Design of Learning Materials

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b. Technology Problem Items

To overcome the problem of using used cardboard waste to create miniature Majapahit buildings based on cultural values, students can use internet technology to search for information. Students can search for internet sites using a cell phone or laptop connected to the internet at school.

Figure 5. Students researching the Internet

c. Engineering Problem Item

The elements related to this technique consist of making a simple miniature ATM design from used cardboard waste that is flat and solid, determining the tools and materials needed to make a simple miniature ATM from used cardboard waste, and the manufacturing process. The steps are as follows:

- Participants listen to the topics presented.
- Participants conduct literacy activities to determine the type of simple miniature ATM-themed plastic recycling crafts they will make and communicate them to the teacher.
- Students sketch a simple design on paper, making sure there are at least flat shapes and solid, interesting designs along with their respective sizes.
- Students prepare the necessary tools and materials.
- Participants measure the cardboard according to their design to create a pattern.
- Students cut the cardboard according to the pattern they created and glue the pieces according to the pattern.
- Participants' added details to the simple miniature ATM they created.
- Participants perfect their miniature ATMs.

d. Elements of Artistic Problems

The artistic element here is related to student creativity, in accordance with the slogan "Save Your Dreams, One Step at the ATM". Characteristics include attractively colored images of animals, plants or houses decorated with bank symbols.

Figure 6. Miniature ATMs with attractive art touches

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e. Elements of Mathematics Problems

The mathematical elements in this lesson are the properties of flat shapes and measurements of length, width and area. Measurement activities can occur during the sketching process and when the ATM miniature is completed.

Arts-Based Physical Education and Mathematics Learning Framework with a PJBL-STEAM Approach in Utilizing Used Cardboard Waste

A. There is no standard syntax in learning ethnomathematics. The steps in learning ethnomathematics can be done according to the local culture. For example, following traditional games, social customs in the community, and others. Whereas PJBL-STEAM is not a learning model. Therefore, there are no specific steps. In this study, the steps of implementing the PJBL-STEAM approach in learning refer to: https://www.youtube.com/watch?v=PKDyqHn_e2Y (accessed on Saturday, November 17, 2022) [14], which can be described as follows:

Table 1. Learning Activity First Stage (Science)

Stage 1	Learning Activities
Focus	a. Students watch a video about "how to save" the existence of used cardboard waste at school (Math and SBdP). b. Students pay attention to the problems presented by the teacher through the projector screen. c. Students read and research each problem one at a time. d. Students can brainstorm general steps to solve the problem presented.

Figure 7. Students watch a video on how to save money

B. Detailing is finding the elements that contribute to an important problem or question. At this stage, students need to gather information to answer the question. At this stage, students need to gather information to answer the question.

Table 2. Learning Activity Second Stage (Technology)

Stage 2	Learning Activities
Detail	a. The students were divided into four groups. b. Students observe the miniature ATMs around them and the pictures provided by the teacher. Students are also allowed to search for information on the Internet. c. The teacher distributes Student Worksheet 1 (SW1) on the Suitability of ATM Miniatures as a guide for collecting relevant information related to student creativity. d. Students record their observations in SW1. e. The teacher goes around and observes each group's work, providing guidance and necessary feedback on the completeness and clarity of each group's information-gathering results.

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Figure 8. Students are divided into four groups

C. Discovery means that students examine the solutions to be provided and existing solutions that have failed to solve the problem.

Table 3. Learning Activity Third Stage (Art)

Stage 3	Learning Activities
Discovery	a. The students were divided into four groups. b. Students observe the miniature ATMs around them and the pictures provided by the teacher. Students are also allowed to search for information on the Internet. c. The teacher distributes Student Worksheet 1 (SW1) on the suitability of students' creativity structure as a guide in collecting relevant information related to ATM miniatures. d. Students record their observations in SW1. e. The teacher goes around and observes the work of each group, giving necessary guidance and feedback on the completeness and clarity of the results.

Figure 9. Students make observations on the Internet

D. Application means that students begin to create a work solution by taking previously learned skills, processes, and knowledge and applying them in practice.

Table 4. Learning Activity Fourth Stage (Mathematics)

Stage 4	Learning Activities
Application	a. Students work in groups to create a miniature ATM product that reflects the artistic nuances of the student's creativity according to the predetermined design. b. Students test their miniature ATM products. c. Students determine the length, width and surface area of their miniature ATM.

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Figure 4. Students collaborate in groups

E. Presentation means that students present the solution or the work they have created in order to receive feedback. Presentation also serves as a means for students to express themselves based on their point of view about the problems they face.

Table 5. Learning Activity Fifth Stage (Engineering)

Stage 5	Learning Activities
Presentation	a. Students work in groups to create miniature ATM products that reflect the student's creativity according to the predetermined design. b. Students determine the length, width, and area of the surface they have created.

Figure 11. Presenting the results of group work

F. Link, which means that students have the opportunity to reflect on the feedback provided, revise their work as needed, and come up with even better solutions.

Table 6. Learning Activity Sixth Stage (Report)

Stage 6	Learning Activities
Link	a. The problem-solving products presented are then displayed in the chart provided for each group. b. Each group makes improvements based on feedback from the other groups. c. Students pay attention to the teacher's reinforcement of the material. d. Students, with the help of the teacher, write the conclusion of the learning material. e. Students work in groups to create a simple miniature ATM product from a given design. f. Students test their miniature ATM products. g. Students determine the length, width and surface area of their miniature ATM.

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Figure 12. Make miniature buildings resulting from student creativity

3.5. Instrument framework for assessing students' creative thinking abilities

The instrument used to measure students' creative thinking abilities is the Student Creativity Observation Sheet. The sheet contains indicators of the creative aspects you want to observe. The three aspects observed are fluency, flexibility and novelty.

Table 7. Framework for Instruments for Assessment of Creative Thinking Ability

Indicator	Sub Indikator	Test Materials
Fluency	a. Problem solving with multiple interpretations, a method of problem solving or a solution. b. Students can provide an appropriate solution to the problem of excessive cardboard waste with an explanation.	How to solve the problem of a lot of cardboard waste in the school?
Flexibility	a. Solve a problem one way and then use a different method. b. Discuss some problem-solving techniques.	The students gave different answers from different points of view related to the problem of excessive cardboard waste in ATM miniatures with the theme of creativity art.
Novelty	a. Explore different problem-solving methods or answers and then create other different answers.	Students can provide a thought-based solution to the problem of excessive cardboard waste by designing their ideas.

Development of Advanced Learning Materials

Further development of learning materials in this research refers to the 4-D development model (4-D model) which consists of four stages, namely definition, design, development and dissemination. The 4-D model was chosen because the stages are sequential, clear, and in accordance with the needs for developing creative arts-based mathematics and SBdP learning materials using the PJBL-STEAM approach. The stages are as follows:

a. Define Stage

There are five main steps in the defining stage: root cause analysis, student analysis, concept analysis, task analysis, and formulation of learning activity objectives. This stage is the first step in creating a math lesson plan based on the art of creativity with the PJBL-STEAM approach.

b. Design Stage

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The design stage aims to prepare the initial form or design of creativity art-based math and SBdP learning tools with a PJBL-STEAM approach to improve students' creative thinking skills, which includes four steps, namely: 1) Develop observation scoring criteria to keep test scoring criteria relevant to the task. 2) The choice of model used in learning is the learning model of mathematics and SBdP based on the art of creativity with the PJBL-STEAM approach. 3) Format selection by customizing the learning model with an appropriate format that is easy to use. 4) The initial design is the initial design or design of the curriculum, lesson plans, LKS, and test sheets for creative thinking skills in problem solving, which includes learning mathematics and SBdP based on the art of creativity with the PJBL-STEAM approach.

c. Develop Stage

The purpose of this stage is to produce the final form of learning devices that have been revised based on the opinions of experts. There are two steps in the development stage, namely 1) expert evaluation followed by revision, 2) development testing.

d. Disseminate Stage

The dissemination stage aims to disseminate mathematics and SBdP learning tools based on the art of creativity with the PJBL-STEAM approach, so that they can be used in several basic education institutions. The socialization of the learning tools will be done through publications in journals, seminars through KKG and uploading learning videos on YouTube.

DISCUSSION

Research conducted by Suganda et al. entitled "PJBL-STEAM and the Environment on Students' Creative Thinking Skills: A Meta-analysis Study" shows that the PJBL-STEAM approach is effective in improving students' creative thinking skills. Their findings are based on a meta-analysis which shows that the combination of PJBL and STEAM has a significant positive impact on students' creative thinking abilities compared to conventional learning methods. Developing a creative arts-based mathematics and SBdP learning framework with a PJBL-STEAM approach to solve waste-related problems is very important and useful, especially for elementary school students who still need to be trained to develop students' creative thinking abilities in an integrated manner. 21st century generation skills. From this research activity there are several things that can be developed further, such as developing mathematics and SBdP learning materials with a deeper understanding of the surrounding culture to improve students' creative thinking abilities while fostering a love of local culture with 4-D, and analyzing students' creative thinking abilities in solving problems. which deals with 2D shapes by utilizing waste to create simple miniature ATMs. This activity framework is effective in improving students' creative thinking abilities, as previous research shows. The use of PJBL-STEAM based learning can improve students' creative thinking abilities, this is in line with research findings conducted by Suganda et al. (2020) with the title PJBL-STEAM and the Environment on Students' Creative Thinking Skills: A Meta-analysis Study. Our research and the research of Suganda et al. shows that the PJBL-STEAM approach is very effective in improving students' creative thinking abilities. However, our research adds a new dimension by integrating local cultural elements and focusing on waste use, which not only increases creativity but also environmental awareness and love for local culture. The use of the 4-D method in developing learning materials also provides advantages in ensuring a systematic and effective approach. Overall, the results of this study support the importance of the PJBL-STEAM approach in basic education to develop 21st century skills.

CONCLUSION

This research highlights the problem situation and syntax or framework of arts-based mathematics learning activities and SBdP with the PJBL-STEAM approach. The framework of the activity includes the use of used cardboard waste to make miniature ATMs as an embodiment of the slogan "Your Dream Tube, One Step at the ATM". This research also contains a test instrument framework with indicators of students' creative thinking abilities. Based on the research process and results, further research related to the development and analysis of the implementation of creative arts-based mathematics and SBdP learning materials using the PJBL-STEAM approach can be carried out more easily.

As a suggestion, teachers need to ensure safety in the use of tools and materials because there are sharp objects used in making miniature ATMs as a manifestation of the slogan "Tubing Your Dreams, One Step at the ATM". Teachers should carry out learning that supports the development of creative thinking abilities and guides students who are slow learners.

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