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Mathematics Learning Based on Traditional Bomboman Games as an Effort to Develop Strategic Mathematical Abilities

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Abstract

This study aims to design and test mathematics learning based on the traditional bomboman game as an effort to develop students' strategic mathematical competence. This research consists of three stages, namely: identification and analysis of traditional games, design of traditional game-based learning based on Realistic Mathematics Education (RME), and implementation in classroom learning involving 34 grade 8 students. Data related to traditional games was collected through observation and interviews with the residents where the game originated. Data on students' strategic mathematical abilities were obtained through tests given after learning. Analysis of student test results refers to indicators of students' strategic mathematical competency. The results showed that 20 students succeeded in fulfilling all indicators of strategic mathematical competence with a very good final grade category. While 14 students succeeded in achieving the first indicator (formulating the problem) but not all of them fulfilled the indicator of representing and solving the problem. The findings of this study indicate that learning mathematics based on the traditional Bomboman game has the potential to help students develop mathematical strategic abilities.

Keywords: *Ethnomathematics, Learning Tools, Realistic Mathematics Education, Traditional Games*

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INTRODUCTION

Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have spiritual religious strength, self-control, personality, intelligence, noble morals, and the skills needed by themselves, society, nation and state (Abdul Latip et al., 2022). Education in Indonesia currently uses an independent learning curriculum which is recommended to behave according to the values of Pancasila which is referred to as the Pancasila student profile.

According to Friedrich Gauss, "mathematics is the queen of science" (Situngkir & Dewi, 2022) so it can be interpreted that mathematics has an important role in the development of other sciences, all sciences must be related to mathematics. One of them is science, namely culture, according to Bishop is a form

of culture and has actually been integrated into all aspects of people's lives wherever they are" "(Nieminen & Atjonen, 2023). Which means that forms of culture and aspects of people's lives cannot be separated from mathematics. Therefore, there is a development science related to mathematics and culture called Ethnomathematics.

Ethnomathematics is a learning approach that is carried out by teaching mathematics by linking mathematics to the cultural works of one's own nation and also involving the needs and lives of its people (Deda et al., 2024). Learning mathematics will be more interesting for students if there is an application in everyday life, one of which is with a culture that is familiar to students, so that it can make it easier for students to understand mathematics (Bustami et al., 2020).

Based on a review of previous research literature to create interesting, enjoyable, and meaningful learning, educators can use an ethnomathematics approach, namely by integrating mathematics with community culture such as temple buildings, traditional houses, dances, batik, ornaments, traditional ceremonies, traditional games and so on (Purohit et al., 2022). Traditional games can help students visualize abstract mathematical concepts into concrete and easy-to-understand ones, and can also improve students' mathematical analysis skills (Adi et al., 2022).

The results of the researcher's observations and interviews with mathematics subject teachers at MTsN 1 Nganjuk revealed that knowledge of ethnomathematics has never been applied by all teachers at MTsN 1 Nganjuk. In addition, from the results of the literature review, the researcher has not found any exploration of ethnomathematics in learning carried out at MTsN 1 Nganjuk. So that it becomes an opportunity for researchers to provide learning innovations at MTsN 1 Nganjuk by exploring ethnomathematics in learning through the traditional game of bomboman.

The traditional bomboman game was obtained by researchers from observations of residents in the Nganjuk Regency area. The results of observations and interviews with residents about this bomboman game are traditional games that are often played by children and adults in the past during the East Javanese kingdom era, with the aim of training the brain in developing war strategies. The bomboman game is usually played against one team, which can be filled with one or more members on condition that the number of members in the team is the same as the opponent. The media used in the bomboman game uses 8 large pebbles and 8 small pebbles called wong, and what distinguishes it from the opponent's wong is that the stone material used is usually river stones and red stones . The bomboman game usually uses a base in the form of wood, paper and a picture on the ground in the form of a square. Large pebbles are behind the small pebbles which are arranged horizontally or horizontally. The rules in the bomboman game are that small pebbles can only walk one step forward, large

pebbles walk one step forward and backward, if you want to eat the opponent's wong you have to step one arena in the game. If the opponent forgets to eat it, the opponent is given a penalty in the form of forcibly taking 3 wong from the opponent according to the opponent's wishes. The game is said to be over if one of the opponents manages to eat all the wong from the opponent, and the game is said to be a draw or tie if both players have 1 wong left each .

Realistic mathematics education learning is a learning approach that involves active student participation in identifying real-world connections to mathematics material, this is also based on Freudental's statement that mathematics is formed by the activities of the social environment of society (Listiawati et al., 2023). Learning with a realistic mathematics education approach is learning that uses constructivism theory which emphasizes the activities and active participation of students in exploring knowledge that has been learned and relating it to real problems to find mathematical concepts (Turmudi et al., 2021). Researchers chose the realistic mathematics education approach because the stages in learning are appropriate and suitable when associated with the traditional bomboman game and students can be directly involved in solving real problems (Halpern & Dunn, 2021).

Based on the description of the problem, a solution is needed to overcome the problem. One of the right ways to overcome the learning process that is not yet optimal is to design valid teaching materials that can facilitate students to understand mathematical concepts based on ethnomathematics in order to increase student appeal and to increase cultural insight to students. Researchers are very interested in culture in terms of traditional games that exist around the environment where researchers live, namely bomboman. This study aims to test mathematics learning based on the traditional bomboman game as an effort to develop strategic mathematical abilities. The subjects of this study were students of class VIII MTsN 1 Nganjuk, as well as mathematics subject teachers. While the object of the study was the mathematics learning process with the integration of traditional bomboman games modified according to the mathematical material of number operations, measurement, or fractions.

METHOD

This study uses a descriptive qualitative approach with the aim of describing the process and impact of implementing traditional games in mathematics learning. This approach was chosen to explore the meaning, experience, and responses of students during traditional game-based learning. The study was conducted at MTsN 1 Nganjuk, during the odd semester of the 2024/2025 school year. The location was selected purposively, because the school is open to learning innovation and has access to local traditional games.

Data collection techniques used include observation to directly observe the learning process, student interactions, and class dynamics when the game is applied; interviews were conducted with teachers and several students to determine their perceptions and experiences of traditional game-based learning; documentation of collecting data in the form of photos, learning videos, and RPP (Learning Implementation Plan) documents used during the study; Learning Outcome Test To determine changes in students' cognitive achievements before and after the application of the method. Data analysis techniques using the (Miles & Huberman, 1994) method include data reduction, namely Filtering data that is relevant to the focus of the study; Data presentation compiling data in the form of descriptive narratives, tables, and graphs; drawing conclusions and verification concluding learning outcomes and student responses to the methods used.

RESULTS AND DISCUSSION

Equations

1. Definition of Ethnomathematics

Ethnomathematics is a method used to study mathematics by involving activities or local culture so that it makes it easier for someone to understand (Nuraina et al., 2021). So it can be interpreted that students find it easy to understand mathematics if they are involved in daily life activities such as the culture in the area where they are studying (Bustami et al., 2020).

Tandililing said "ethnomathematics has a broader meaning than just ethno (ethnicity) or tribe, if viewed from a research perspective, ethnomathematics is defined as cultural anthropology (cultural anthropology or mathematics) of mathematics and mathematics education" (Arliani & Khabibah, 2022). Therefore, it is a very appropriate choice to use culture in studying mathematics, there are several cultural concepts found in batik cloth, traditional games, weaving, buildings, traditional houses, and so on (Handayani & Irawan, 2021).

2. The Role of Ethnomathematics in Mathematics Learning

a. Ethnomathematics facilitates students to be able to construct mathematical concepts with prior knowledge that they already know through their own environment.
b. Ethnomathematics provides a learning environment that creates good motivation, is fun and free from the assumption that mathematics is scary.
c. Ethnomathematics is able to provide affective competence in the form of creating a sense of appreciation, nationalism and pride in the nation's traditional, artistic and cultural heritage.
d. Ethnomathematics supports students' abilities in accordance with the expectations of implementing a scientific approach (Sugandi et al., 2023).

Ethnomathematics has an important role to support the mathematics learning process, students are not only faced with concepts or theories in mathematics learning but can learn directly from conditions in the community environment or see the remains of buildings in the surrounding environment. In

addition, students can also understand clearly and clearly from what students see in the environment, such as seeing a historic building or seeing the patterns in making batik cloth. By seeing everything in society, love for the homeland and pride in the relics of ancient people will arise. With Ethnomathematics, it is hoped that students will be able to face all changes in conditions or challenges in life that are always changing and developing (Handayani & Irawan, 2021).

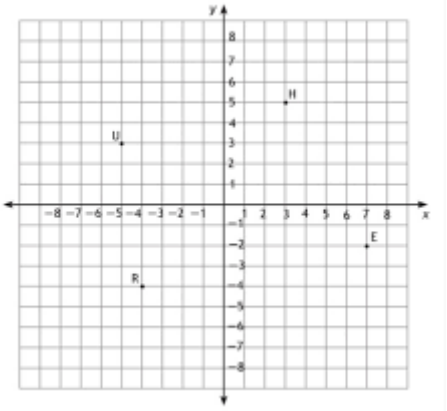
Cartesian Coordinate System

1. Understanding the Cartesian Coordinate System

Cartesian coordinates are two axes that are perpendicular to each other (Luo et al., 2022). On the axis lies in one plane (plane xy), the *horizontal axis* or commonly called the axis x, and the *vertical axis* or axis y. The point of intersection on the axis $x$and $y$is called the origin which is commonly known as the zero point.

Positive numbers on the axis $x$start from zero to the right and so on while *negative numbers* on the axis $-X$start from zero to the left and so on. While positive numbers on the axis $-Y$start from zero and negative numbers on the Y-axis start from zero down. Coordinates $x$are usually called (abscissa) and coordinates $y$are called (ordinates).

Picture 2.1 Cartesian coordinates



In the Cartesian coordinate plane, the x and y axes are divided into four quadrants, namely:

Quadrant I: $-X$ *Positive coordinates* $(+)$and negative coordinates$-Y$ *positive* $(+)$
Quadrant II: Coordinates $-X$ *negative* $(-)$and coordinates$-Y$ *positive* $(+)$
Quadrant III: Coordinates$-X$ *negative* $(-)$and coordinates$-Y$ *negative* $(-)$
Quadrant III: $-X$ *Positive coordinates* $(+)$and coordinates $-Y$ *negative* $(-)$

2. Point Position Regarding X Axis and Y Axis

The position of a point in Cartesian coordinates is written in ordered pairs (x, y). The number x indicates the distance of the point from the Y axis and the number y indicates the distance of the point from the X axis (Junior High School Mathematics/MTs Class VIII. 2017).

Example 1: Determine the position of the point on the Cartesian coordinate plane below! Pay attention to the point E, H, R, U in **Picture 2.1** with respect to the axis $X$and$Y$

The solution:

- Point E $(7,-2)$.So the point Ehas a 7unit distance to the axis $Y$and 2a unit distance to the axis$X$
- Point H. (3,5)Then the point Hhas 3a unit distance to the axis $Y$and 5a unit distance to the axis.X
- Point R. $(-4,-4)$Then the point Rhas 4a unit distance to the axis $Y$and 4a unit distance to the axis.X
- Point U $(-5,3)$.So the point Ehas a 5unit distance to the axis $Y$and 3a unit distance to the axis$X$

***Bomboman* Traditional Game**

Bomboman game is a traditional game that is often played by children and adults in the past during the East Javanese kingdom, with the aim of training the brain in devising war strategies. The *bomboman game* is usually played against one team, which can be filled with one or more members, provided that the number of members in the team is the same as the opponent. The media used in the *bomboman game* uses 8 large pebbles and 8 small pebbles called *wong,* and what distinguishes it from the opponent's *wong* is the stone material used, usually river stones and red stones (Adi et al., 2022). *The bomboman* game usually uses a base in the form of wood, paper and a picture on the ground in the form of a square. Large pebbles are behind the small pebbles arranged horizontally or horizontally. The rules in the *bomboman game* are that small pebbles can only walk one step forward, large pebbles walk one step forward and backward, if you want to eat the opponent's *wong* you have to step one arena in the game. If the opponent forgets to eat it, the opponent is given a sanction in the form of forced taking of 3 *wong* from the opponent according to the opponent's wishes. The game is said to be finished if one of the opponents succeeds in eating all of the opponent's *people , and the game is said to be a draw or draw if both players leave 1 person* each.

Illustrations

Local Game Identification and Analysis Stage

The first stage aims to find out the history of a traditional game called *bomboman*, the steps of the game, and the possibility of its application in mathematics learning. The researcher observed the game and interviewed one of the residents in Bogo Village, Nganjuk District, Nganjuk Regency, Indonesia. The place is considered to be the origin of the game. The interview was recorded for further analysis and comparison with other available sources of the game's history (Jensen & Andreasen, 2020).

Local Game-Based Learning Development Stages

At this stage, the researcher designed mathematics learning for grade VIII students from learning activities, learning tools, and strategic competency indicators.

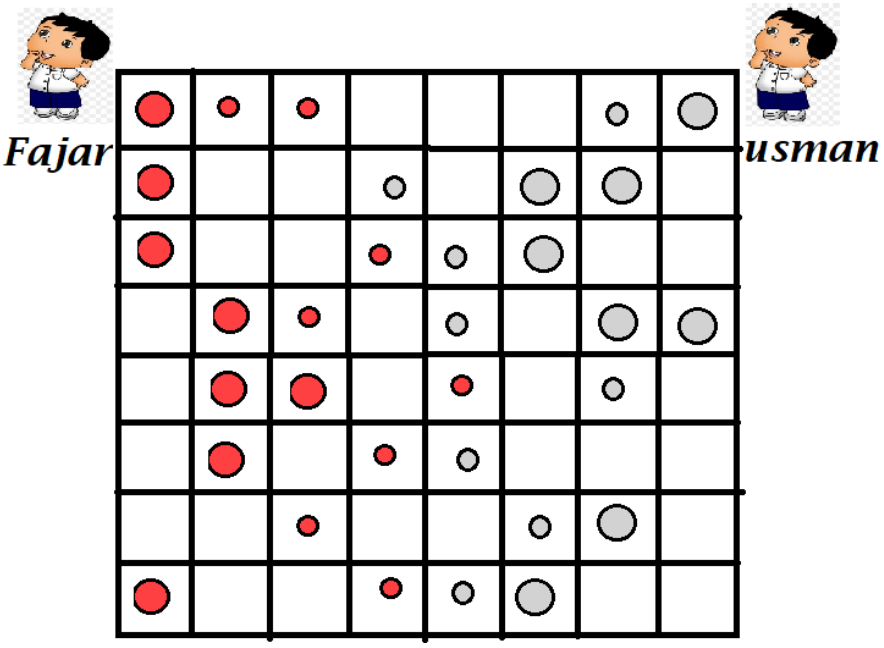
Learning Activities

The five principles of RME are used as a reference in preparing learning activities (Angraini & Muhammad, 2023). The basic competencies to be achieved in learning are identifying the concept of Cartesian coordinates, describing the steps of drawing points on Cartesian coordinate , identifying the concept of distance between two points on the Cartesian plane (Demirdzic et al., 1987).

Table 1. Designed learning activities

No.	RME Principles	Learning Steps
1.	Use of real world context in learning	The teacher communicates the learning objectives and the role of the game. Students in groups are given worksheets containing mathematical tasks on the topic of Cartesian coordinates that must be completed. The mathematical tasks are intentionally linked to the game.
2.	Use of models	Using worksheets, students are encouraged to create pictorial representations to help complete math tasks.
3.	Student contribution to learning	Students form groups of 4-5 people. Students play *bomboman* while observing and recording things related to the LKS.
4.	Interactive learning activities	Students in groups discuss mathematical ideas in the game to complete the mathematical tasks in the LKS; after this, a whole-class discussion is also carried out.
5.	Interrelationship between topics	Students determine plans to solve problems related to everyday life.

The researcher designed learning tools to support learning activities: a lesson plan, a test to test students' strategic mathematical competence, and student worksheets, consisting of mathematical tasks. The details of the lesson plan are not presented in this article, but they fully follow the predetermined learning activities. The tests developed to test students' strategic competence are as follows.



Fajar and Usman play *bomboman*. The *bomboman game* played by Fajar and Usman has not attacked/eaten each other. In this position, it is Fajar's time to step forward to run his *wong* and there is an opportunity to eat Usman's wong. Based on this game, a problem will be given as follows:

1. Write down the location of each Cartesian coordinate for each small and *large person* owned by Usman!
2. Describe *the people* that Fajar can eat based on the location of the Cartesian coordinates!
3. Which *person* from Fajar and Usman has gone the furthest? and mention the coordinates from the starting position to the end!

In the student worksheet the researcher developed mathematical tasks to be completed by students in groups. The tasks were to identify the concept of Cartesian coordinates, describe the steps of drawing points on Cartesian coordinates, identify the concept of distance between two points on the Cartesian plane.

Mathematics Strategic Competence Indicators

Three aspects representing seven strategic competence indicators were coded (Susanti et al., 2020). This was used as a reference to determine the development of students' mathematical strategic competence. The three aspects (formulating, representing, and solving problems) are hierarchical because every problem solving begins with problem formulation, then representation mediates students to formulate strategies and solve problems (Widyanti & Khabibah, 2020).

Table 2. Strategic Competence Indicators

Strategic competence	Indicator	Coding
Formulate problem	1. Students can understand the situation or context of the problem given. 2. Students can find information and ignoring irrelevant issues 3. Students can present mathematical problems in various forms.	M1
Representing the problem	1. Students can find mathematical relationships that exist in a problem.	M2
Solve the problem	1. Students can find solutions to problems	M3

At this stage, the researcher acted as a teacher to teach 34 eighth grade students using learning activities designed in two lesson hours. Table 3 is used to categorize students' strategic competence based on test results. To analyze students' strategic competence based on test results, the researcher connected Table 2 and Table 3 using a holistic assessment rubric. Students' answers that meet one of the indicators are given a score of 4, then the maximum score with 5 indicators is 20. Answers that do not meet the indicators are given a score of 0. For analysis purposes, students who meet all three aspects of strategic competence or

all five aspects of the indicators are given the code KST. Students who can meet several indicators are given the code KSR. For example, if a student meets the first aspect consisting of two indicators but cannot meet the other two aspects (five indicators), then he is included as KSR.

Table 3. Students' Strategic Competence Level

Student Score	Competency Level
16 – 20	Very good
11 – 15	Good
6 – 10	Enough
0 – 5	Not enough

Discussion

Exploration of Ethnomathematics in Learning

Learning was conducted in class VIII G MTsN 1 Nganjuk attended by 34 students, the role of the researcher as a teacher so that he was directly involved in the learning process. The learning that took place used the 2013 curriculum with the Realistic Mathematic Education (RME) learning model (Riskayanti & Samsudin, 2023). The basic competencies and learning indicators used are as follows:

Table 4. Basic competencies and Cartesian coordinate indicators

Basic competencies		Indicator	
3.2	**Explaining the position of points in the Cartesian coordinate plane which is related to contextual problems.**	3.2.1	Identifying the concept of Cartesian coordinates
		3.2.2	Describes the steps for drawing points in Cartesian coordinates
		3.2.3	Identifying the meaning of the distance between two points on the Cartesian plane

The stages of realistic mathematics education that take place in class are as follows (Nuraina et al., 2021).

a. Motivating student learning and communicating the benefits of learning objectives for Cartesian coordinates in everyday life.
b. Describe and communicate the procedures for playing *bomboman* in learning, the *bomboman game* chosen is in accordance with real problems and in accordance with the experience and level of knowledge of students.
c. Students make a bomboman game arena on paper using markers and rulers. After the game arena is finished, students look for 8 large pebbles and 8 small pebbles, then students arrange the pebbles in the game arena.
d. Learning is running actively and effectively, it can be seen from the interest and enthusiasm of students in playing *bomboman* . As well as the way students solve problems from the teacher by drawing and determining concepts, steps to draw points, and the distance between two points on the Cartesian coordinates in the *bomboman game arena* .

Students participate actively and interactively in learning, this can be seen from the way students find Cartesian coordinates, and describe the answers and

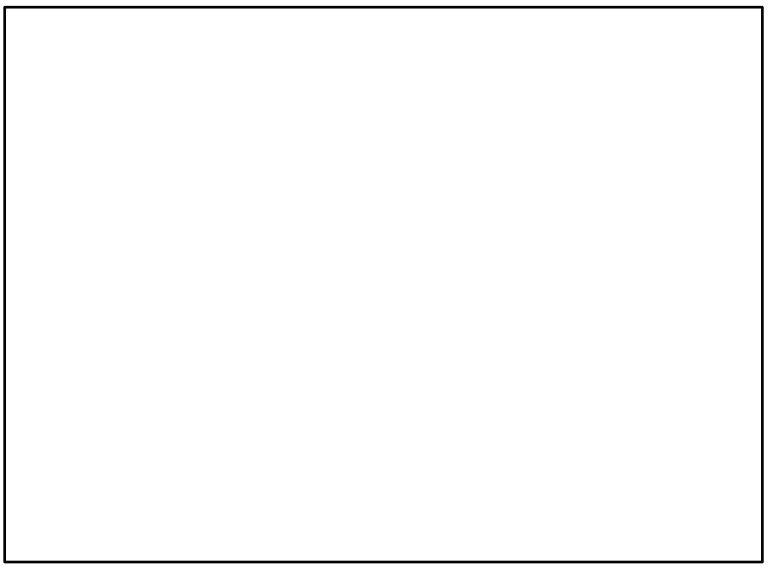
understand their friends' answers by expressing opinions and exchanging ideas to solve problems.

Explore How to Create a Match Arena:

The arena usually uses paper, wood and soil media. But in modern times like this some people usually use chess because the board and the number of columns and rows are the same. Because this is an exploration, the researcher will explain how the traditional way of making a traditional bomboman game arena with paper media.

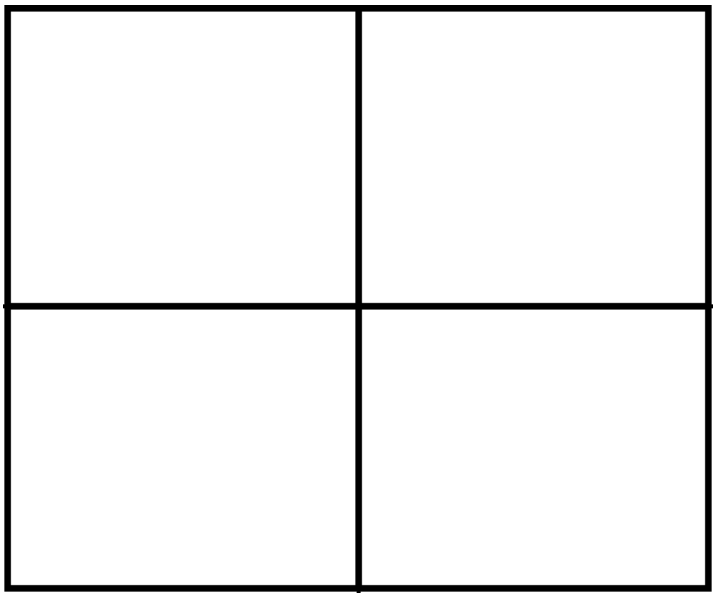
1. Make or draw a square on paper.

Picture 4. 1 step 1 creating a bomboman game arena



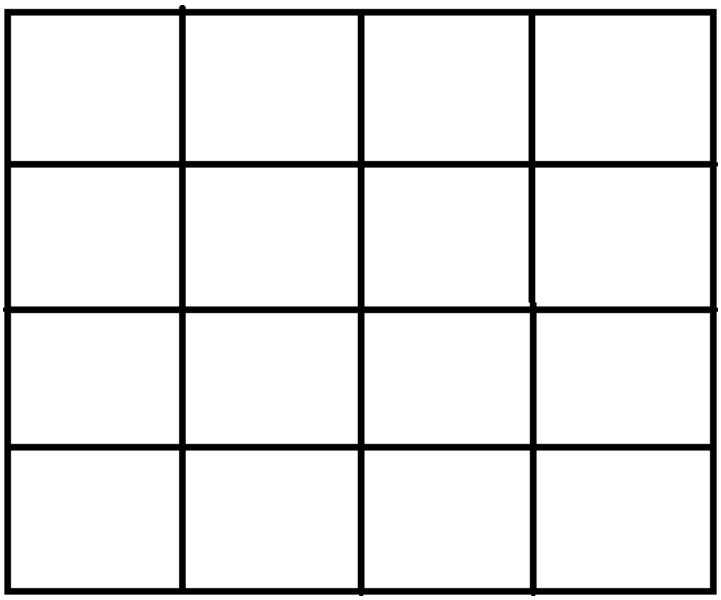
2. Divide the square vertically and horizontally into equal sizes, as shown in the following image.

Picture 4.2 step 2 creating a bomboman game arena



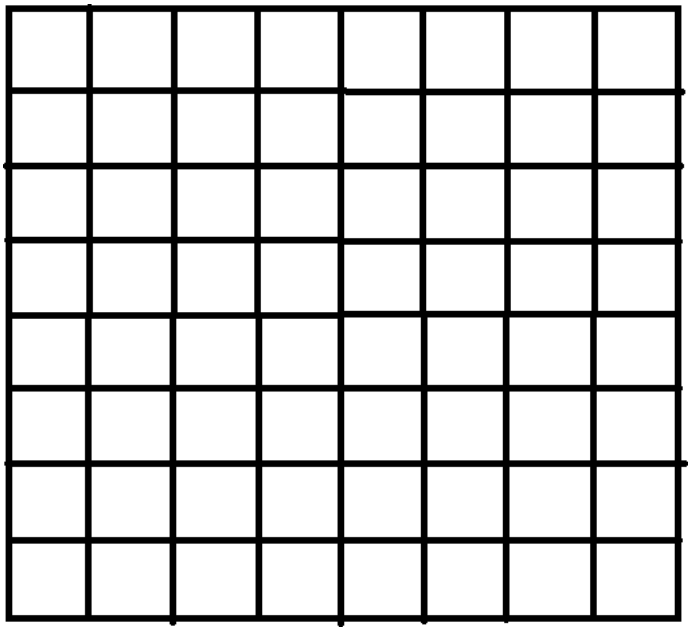
3. divide each row and column into 2 vertical lines and 2 horizontal lines of the same size.

Picture 4. 3 steps 3 creating a bomboman game arena



4. Divide each row and column vertically and horizontally into equal sizes.

Picture 4. 4 Step 4: Create a Bomboman game arena



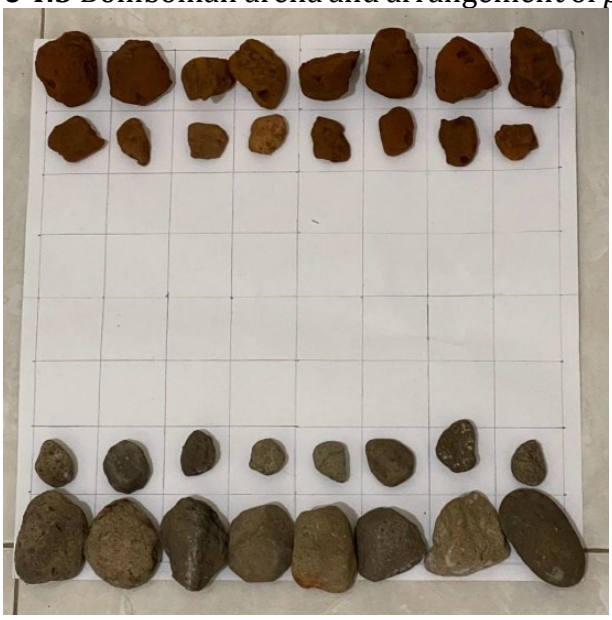
In making the arena, the mathematical concept can be known, namely in the first step, making a square which means there is 1 area. The second step, the square is divided by two lines vertically and horizontally with the same size, meaning there will be 4 areas, so it can be interpreted as 2^2 because there is a division of 2 lines in a square vertically and horizontally intersecting. The third is dividing each row and column into 2 vertical lines and 2 horizontal lines with the same size, so there will be 16 areas, which can be interpreted as 4^2 because there is

a division in the previous area of 4 lines. The fourth is dividing each row and column into 4 vertical lines and 4 horizontal lines with the same size, so there will be 64 areas, which can be interpreted as 8^2 because there is a division in the previous area of 8 lines.

How to play and rules:

1. Determining the player and the player's opponent
2. Each player arranges *the people* in the 2 rows at the very edge facing the opponent, in the back row there are 8 large *people* , and in front there are 8 small *people* .

Picture 4.5 Bomboman arena and arrangement of *people*

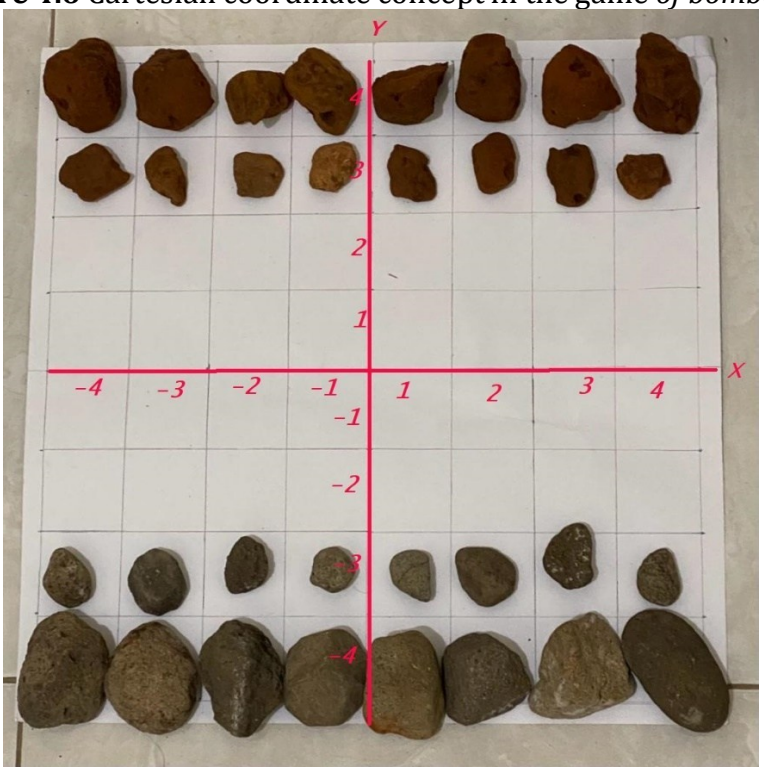


3. Players determine who goes first by either tossing a suit or choosing a coin toss.
4. Players take turns running the game and strategizing how to eat the opponent's game.
5. People can only walk one step forward, and what differentiates big people from small people is that big people can step forward and backward while small people can only walk forward, and if the small people have occupied the opponent's big person, then the small person can turn into a big person.
6. The way to eat the opponent's *wong* is by jumping over the opponent's *wong* one step, and if the opponent forgets to eat the wong then he will be punished by forcibly taking 3 *wong* from the opponent who forgot to eat the *wong*.
7. The game is said to be finished if one of the opponents succeeds in eating all of the opponent's *wong*, and the game is said to be a draw or draw if both players leave 1 person each.

Mathematical concepts in the game of bomboman

One of the mathematical concepts in the bomboman game is the Cartesian coordinate material which can be seen in Picture 4.6 that the researcher assumes the rows and columns in the bomboman game arena as ordinate and abscissa units on the Cartesian plane, if divided into 4 areas it will become quadrants I, II, III, and IV in Cartesian coordinates.

Picture 4.6 Cartesian coordinate concept in the game *of bomboman*



In applying mathematical concepts in this bomboman game, students will be given problems in the form of:

1) Identifying the concept of Cartesian coordinates according to the arena in the game of bomboman
2) Describes the steps for drawing points on coordinates based on how to create an arena in a Cartesian coordinate game.
3) Identifying the meaning of distance between points on the Cartesian plane

Students' mathematical strategic competence

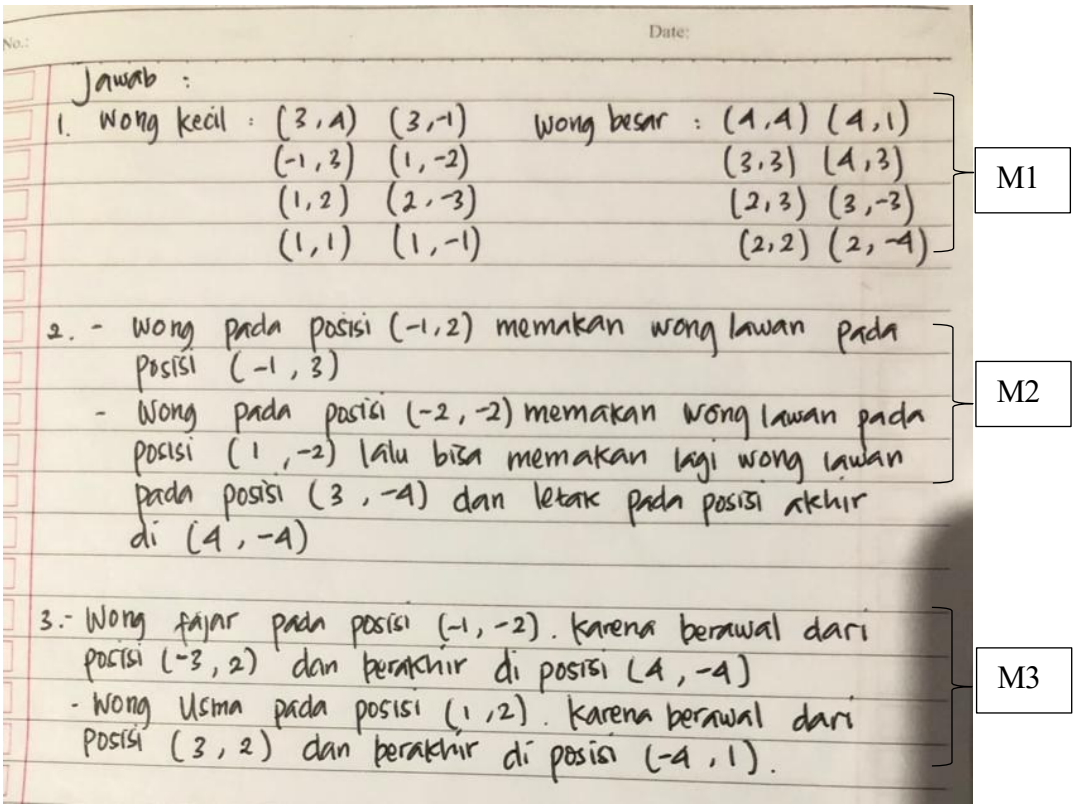
Competence was measured using a test after two lessons with *bomboman* . Table 5 shows the students' scores on the test. There were 20 students (coded KST) who achieved all indicators. While 14 students (coded KSR) met M1 (formulating problems) but had not completed M2 (representing problems) and M3 (solving problems) completely.

Table 5. Students' test scores

Student scores	Frequency	Percentage(%)	Category
16-20	20	58.8	Very good
11-15	14	41.2	Good
6-10	0	0	Enough
0-5	0	0	Not enough
Total	20	100	
Average	15.9	Very good	

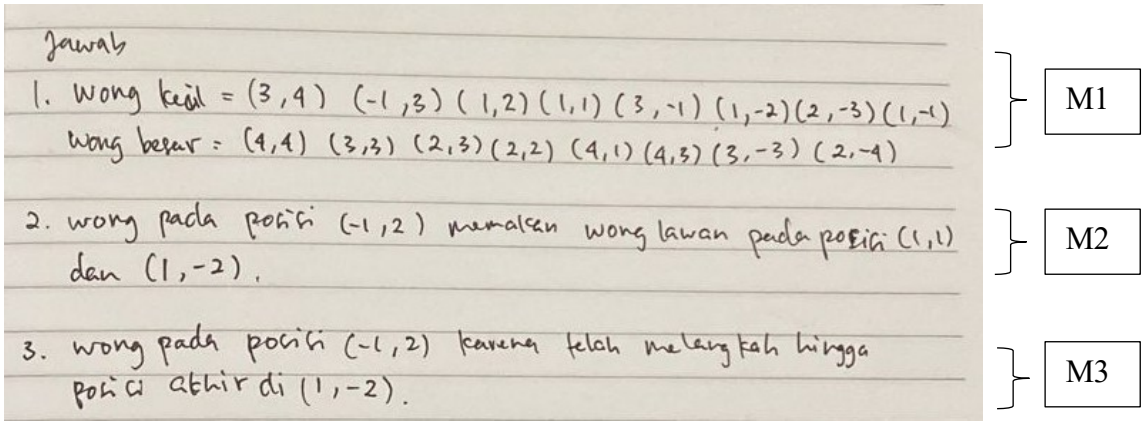
In Picture 4.7, KST students formulate the problem correctly (M1). Students understand the given problem and find the location of each Cartesian coordinate of the small and large wong owned by Fajar. Also, students present the problem (M2) by describing the steps of the wong from Fajar to eat the wong from Usman in detail. Furthermore, students solve the problem (M3) by knowing the location and direction taken, so students can solve the furthest distance traveled by the wong from the starting point to the end.

Picture 4.7. The results of one of the KST students' answers



In Picture 4.8, KSR students formulate the problem correctly (M1), which includes three indicators, namely understanding the situation or context of the problem, finding information , and presenting the problem. Students at the next stage (M2) students are correct in writing the location but wrong in the rules of the bomboman game that actually the little guy is not allowed to walk or eat backwards. And at stage M3 the student's answer is not in accordance with the rules of the bomboman game but actually the student understands the meaning of the Cartesian coordinate location.

Picture 4.8 . results answer one KSR students



From the researcher's observation, it is actually easier for students to understand the application of this Cartesian coordinate material using the bomboman game. It's just that students are still unfamiliar with this game and need to be introduced for a long time so that students can understand the game first. The results of the KST students are correct but are not careful in finding M2, one answer should be missing to perfect the answer. The perfect answer is that the person at point (-1,2) can eat 5 opponents from the opponent, namely the person at point (1,1) (3,1) (4,1) (3,-1) and (1,-2). In this study, students who previously understood the Cartesian coordinate material tended to be confused by the rules of the game so that they made mistakes in solving the problem. In general, students understand the Cartesian coordinate material better than the rules of the game, researchers who act as teachers should apply this game to introduce the Cartesian coordinate material at the beginning of the lesson before entering the material.
Although the local game-based learning developed supports most students in developing strategic competence, the researcher argues that the two lesson hours are not representative enough to conclude the effectiveness of the designed learning activities. In this case, it needs to be revised to answer the needs of students who have not achieved all indicators of strategic competence. Then, further empirical trials involving more students and lessons are certainly needed

CONCLUSIONS

In this study, researchers developed local game-based mathematics learning to develop students' strategic competence in learning Cartesian coordinate material. This game can be done practically because the tools and materials used are easy to find in the school environment. The test results showed that most students were able to formulate, represent, and solve Cartesian coordinate problems based on the bomboman game . However, some students had difficulty in determining mathematical ideas in the game and choosing the right strategy to solve problems in the test which hindered students' ability to solve problems. Researchers identified errors in understanding the rules of the game so that

students had difficulty in describing and completing answers correctly and in accordance with the rules of the bomboman game. Actually, all students already understand the Cartesian coordinate material because it clashes with quite a lot of rules in the bomboman game so that students have difficulty in presenting and completing their answers.

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