

## Designing culturally-rich local games for mathematics learning

Elly Susanti<sup>1</sup>, Nur Wiji Sholikin<sup>1</sup>, Marhayati<sup>1</sup>, Turmudi<sup>1</sup>

**Abstrak:** Penelitian ini bertujuan merancang dan mengujicoba pembelajaran matematika berbasis permainan tradisional (*das-dasan*) sebagai upaya untuk mengembangkan kompetensi strategis matematis siswa. Penelitian ini terdiri dari tiga tahap, yaitu: identifikasi dan analisis permainan tradisional, perancangan pembelajaran berbasis permainan tradisional berdasarkan *Realistic Mathematics Education* (RME), dan implementasi dalam pembelajaran di kelas yang melibatkan 20 siswa kelas 7. Data terkait permainan tradisional dikumpulkan melalui pengamatan dan wawancara dengan lima warga tempat permainan tersebut berasal. Data kemampuan strategis matematis siswa diperoleh melalui tes yang diberikan setelah pembelajaran. Analisis hasil tes siswa merujuk pada indikator kompetensi strategis matematis siswa. Hasil penelitian menunjukkan 15 siswa berhasil memenuhi semua indikator kompetensi strategis matematis dengan kategori nilai akhir sangat baik. Sedangkan 5 siswa berhasil mencapai indikator pertama (merumuskan masalah) namun belum semua memenuhi indikator merepresentasikan dan menyelesaikan masalah. Temuan penelitian ini menunjukkan bahwa pembelajaran matematika berbasis permainan tradisional *das-dasan* memiliki potensi untuk membantu siswa mengembangkan kemampuan strategis matematis.

**Kata kunci:** *Rancangan pembelajaran, Etnomatematika, Permainan tradisional, Das-dasan, RME*

**Abstract:** This study aimed to design and implement local games-based mathematics learning (*das-dasan*) to support students' mathematical strategic competence. It consisted of three stages, namely the identification and analysis of the traditional game, the design of learning activities based on Realistic Mathematics Education (RME), and the implementation in the classroom which involved twenty 7<sup>th</sup>-grade students. Data about the local game was collected through observations and interviews with five residents where the game is originated. Data on students' strategic competence was achieved through a test given to the students after learning. The analysis of test results refers to the indicators of strategic competence. The present study found that fifteen students are able to achieve all indicators (formulating, representing, and solving the problems) with high scores. Meanwhile, five students could only represent the problems but have not fulfilled the last two indicators. The findings of this study indicate that learning mathematics based on traditional *das-dasan* games has the potential to help students develop strategic competence.

**Keywords:** *Learning design, Ethnomathematics, Local game, Das-dasan, RME*

### A. Introduction

Ethnomathematics is a culture-oriented learning study and has the objective to explore mathematical concepts in the socio-cultural activities of the community (Rosa & Orey, 2011; Tereshkina et al., 2015). The culture can be in the form of language, dance, games, traditional houses, and various types of regular community activities that can be linked to mathematics

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<sup>1</sup> Department of Mathematics Education, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Jln. Gajayana 50 Malang 65144, [ellysusanti@mat.uin-malang.ac.id](mailto:ellysusanti@mat.uin-malang.ac.id)

learning so that it has a significant role in developing students' mathematical abilities (Anderson-pence, 2015; Ismail & Ismail, 2010; Maryati & Pratiwi, 2019; Nofrianto, 2015; Risdiyanti & Prahmana, 2018). Mathematics learning integrated with community culture promote students' abilities in exploring mathematical concepts (Brandt & Chernoff, 2015; Saldanha, Kroetz, & de Lara, 2016; Rosa & Orey, 2017). Indeed, community culture can be utilized to support students in learning mathematics, one of which is a traditional game.

Prior studies (Riberio, Palhares, & Salinas, 2020; Nkopodi & Mosimege, 2009; Tatira, Mutambara, & Chagwiza, 2012) found that students could actively participate in learning using traditional games to construct new knowledge by linking acquired knowledge with prior experiences. Moreover, learning with traditional games can develop students' imagination and creativity in thinking to understand mathematical concepts independently, such as geometric shapes, patterns, and line positions (Bandeira, 2017; Fouze & Amit, 2018; Zaenuri, Teguh, & Dwidayati, 2017). From these results, it can be concluded that learning mathematics with traditional games makes learning more meaningful and effective.

Considering the didactic aspect of traditional games in mathematics learning, the present study developed local game-based mathematics learning. The local games, called *das-dasan*, is one of the traditional games in Indonesia which has didactic potential to support students learn geometry. The tenets of RME (Gravemeijer, 1994): the use of the real-world context in learning, the use of models, students' contributions in learning, learning activities take place interactively, and linkages between learning topics were used can encourage students to learn geometry. A number of studies (Gravemeijer & van Eerde, 2009; Palupi & Khabibah, 2018; Shandy, 2017; Sitorus & Masrayati, 2016; Yuniati & Sari, 2018) have shown that RME help students link mathematical concepts with real-world contexts and rediscover geometry ideas and concepts independently through students' exploration.

Several studies (e.g., Helsa & Hartono, 2011; Jaelani, Putri, & Hartono, 2013; Nursyahidah, Putri, & Somakim, 2013) used RME with traditional games to support students learn varied topics. Jaelani et al. (2013) utilized traditional *gasing* game to help students' reinvention of time measurement historically. In the other context, Nasrullah and Zulkardi (2011) foster students' understanding of counting using a local game called *Bermain Satu Rumah*. Also, Nursyahidah et al. (2013) developed learning activities to promote students' understanding of addition up to 20 using *Dakocan* game. The present study is similar to the studies above regarding the use of RME but employ different traditional games to develop students' mathematical strategic competence in rectangle and triangle topic. We argue that different traditional games which have didactical functions should be promoted and used in mathematics learning. Besides targeting the effectivity of instructional practices, it also preserved the traditional games amid the massive emergence of digital games.

The present study aimed to develop students' mathematical strategic competence using the designed traditional games-based mathematics learning. Mathematical strategic competence is students' ability to formulate, represent, and solve mathematical problems. It is not different with problem-solving and problem formulation, which are commonly known in the literature of mathematics education (Kilpatrick, Swafford, & Findell, 2001). Strategic competence is one of the strands of mathematical proficiency developed for a large scale research project involving students from pre-kindergarten to grade 8. This competence is pivotal for students when they might find situations outside of school, which are needed to be formulated and solved using mathematics.

## B. Methods

The present study followed three stages: the local game identification/analysis stage, the step of designing local game-based learning, and the implementation phase in classroom learning.

### 1. Local game identification and analysis stage

The first stage aimed to find out the history of the traditional game, called *das-dasan*, the steps of the game, and the possible implementation in mathematics learning. We observed the game and interviewed five residents in Gebang sub-village, Sukorame village, Sukorame sub-district, Lamongan regency, Indonesia. The place is considered as the origin place of the game. The interviews were recorded to be further analysed and compared with other available resources of the history of the game.

### 2. The stage of developing local game-based learning

At this stage, we designed mathematics learning for 7<sup>th</sup>-grade students which consist of learning activities, learning tools, and the indicators of strategic competence.

#### Learning activities

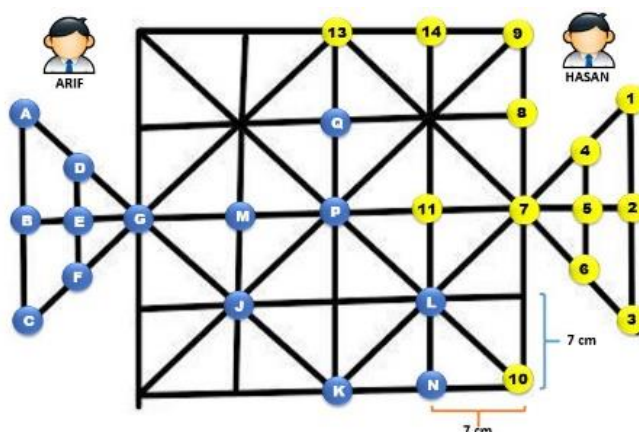
Five tenets of RME (Gravemeijer, 1994) were used as a reference in preparing the learning activities (Table 1). The basic competence to be achieved in the learning is linking the circumference and area for various types of rectangles (rectangles, rhombus, parallelogram, trapezoid, and kite) and triangles. In addition to the basic competence, the learning goals are the students are (1) able to recognize and understand the types of rectangles and triangles, (2) able to name and find rectangles and triangles in the surrounding environment, and (3) able to solve the problems related to rectangle and triangle.

**Table 1.** The designed learning activities

No.	RME Tenets	Learning steps
1	The use of real-world contexts in learning	The teacher communicates the learning objectives and the roles of the game. The students in a group are provided with a worksheet which comprises mathematics tasks about triangle and rectangle topics to be accomplished. The mathematics tasks are deliberately linked with the game.
2	The use of models	Using the worksheet, students are encouraged to create pictorial representations to help solve mathematics tasks.
3	Student contributions in learning	Students form groups of 4-5 member. Students play the <i>das-dasan</i> game while observing and taking notes on matters relating to the worksheet.
4	Interactive learning activities	Students in the group discussed the mathematical ideas in the game to solve mathematics tasks in the worksheet; following this, the whole-class discussion is also administered.
5	Linkages between learning topics	Students determine the planes to solve the problems related to daily life.

## Learning tools

We designed the learning tools to support the learning activities: learning plans, a test to examine students' mathematical strategic competence, and students' worksheet, which comprise mathematics tasks. The detail of learning plans is not presented in this article, but it fully follows the designated learning activities (Table 1). The developed test to examine students' strategic competence is as follows.



Arif and Hasan are playing das-dasan. The game gets exciting, uwong<sup>2</sup> Arif and uwong Hasan eat each other. When the game goes fun, Arif forgets that uwong (L) eats uwong (11), Arif runs uwong (Q) going forward, then Arif got hit with Das, and as his penalty, Hasan has the right to take Arif's three uwong. Hasan could eat Arif's more uwong, Hasan took uwong (P, G, and K). Next, Hasan runs uwong (10) eating uwong (L, M, J, and N). So far, Hasan managed to get 7 Arif's uwong consisting of 3 fines and four eating results. Based on the das-dasan game played by Arif and Hasan.

- What plane was formed by Hasan's uwong (10)?
- Determine and evaluate the area formed by uwong (10)!
- In the das-dasan game arena, make a minimum of 3 different rectangular ways which has the same area as the plane formed by uwong (10).

In the students' worksheet, we developed mathematics tasks to solve by the students in the group. The tasks are to (1) draw the rectangles and triangles formed in the *das-dasan* game arena, (2) list as many as rectangles and triangles found in the *das-dasan* game arena, and (3) formulate steps to get the number of rectangles and triangles on the *das-dasan* game arena.

## The indicators of mathematics strategic competence

Three aspects representing the seven indicators of strategic competence (Kilpatrick et al., 2001) were coded (Table 2). It was used as a reference to determine the development of students' mathematical strategic competence. The three aspects (formulate, represent, and solve the problems) are hierarchy in nature since every problem-solving begin with problem formulation, then representation mediates the students to prepare strategies and solve the problem.

<sup>2</sup> *Uwong* is defined as a person or pawn.

**Table 2.** The indicators of strategic competence

Strategic competence	Indicators	Coding
Formulate the problems	<ol style="list-style-type: none"> <li>1. Students can understand the situation or context of the given problem</li> <li>2. Students can find key information and ignore irrelevant ones of a problem</li> <li>3. Students can present mathematical problems in various forms</li> </ol>	M1
Represent the problems	<ol style="list-style-type: none"> <li>1. Students can choose the presentation that is suitable to help to solve the problem</li> <li>2. Students find mathematical relationships that exist in a problem</li> </ol>	M2
Solve the problems	<ol style="list-style-type: none"> <li>1. Students can choose and develop effective methods of problems solving</li> <li>2. Students can find solutions to the given problems</li> </ol>	M3

### 3. The implementation in classroom learning

At this stage, we acted as a teacher to teach 20 seventh-grade students using the designed learning activities in two lessons. Table 3 was used to categorize students' strategic competence based on the results of the test. To analyse students' strategic competence based on the test results, we link Table 2 and Table 3 using a holistic assessment rubric. Student's answer which fulfilled one indicator was scored 4, then the maximum score with 7 indicators was 28. The answer that did not meet the indicator is scored 0. For the purpose of analysis, students who meet the three aspects of strategic competence or all seven indicators are coded KSM. The students who could fulfil several indicators are coded TSM. For example, if a student meets the first aspect, which consists of two indicators but unable to fulfil the other two aspects (five indicators), then he/she is included as TSM.

**Table 3.** Level of students' strategic competence

Student scores	Level of strategic competence
24 – 31	Very good
16 – 23	Good
8 – 15	Enough
0 – 7	Less

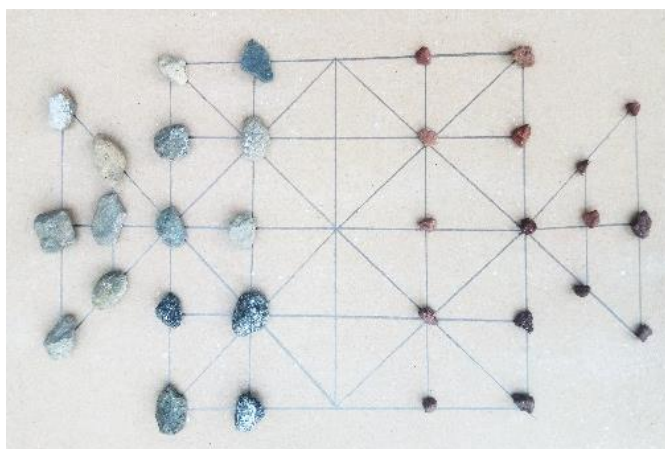
### C. Findings and Discussion

In this section, we firstly provide a description of the *das-dasan* game and the highlight of students' works in the group. Afterwards, we present students' achievement on strategic competence, referring to the results of the test, following by a discussion of this study.

#### *Das-dasan* game

The results of direct observation and interviews resulted in the following basics game description. The game of *das-dasan* is a traditional game in the kingdom of East Java, played in pairs to train the sharpness of thinking and set the strategy for the war. The *das-dasan* game has 32 *uwong-uwongan* consisting of 16 *uwong* from small pebbles and 16 *uwong* from large rocks. The rules in *das-dasan* games are as follows.

1. Two players play the set of *das-dasan*
2. Before the game starts, the player first arranges the *uwong-uwongan* right at the intersection line of the game arena.
3. The player determines who has the right to run the *uwong* first in a suit.
4. Players run alternately *uwong* while setting strategies to be able to eat the opponent's *uwong*.
5. If a player forgets not to eat the opponent's *uwong* when given the bait, then it is said to be *das* so that the opponent has the right to take three *uwong* as he wishes (which needs to be considered when taking three *uwong*, namely by thinking of a strategy so that he can eat more *uwong*).
6. If *uwong* from one of the players can enter the opponent's triangle arena and walk around the stadium three times, then *uwong* can become king and can walk, jump away, and eat the opponent's *uwong* as desired.
7. *Uwong* can become king automatically if only one left.
8. Players are said to win if they can eat up the opponent's *uwong*.



**Figure 1.** The arena of *das-dasan* and *uwong*

The linkage of *das-dasan* games with rectangle and triangle topic can be seen in the arena of *das-dasan* games presented in [Figure 1](#). In the park of *das-dasan* games, several lines form a rectangular and triangular shape. *Uwong*, which is arranged in the arena of *das-dasan* games when followed by connecting one *uwong* with another *uwong*, can also form rectangular and triangular illustrations. The purpose of the game itself, which is to train one's sharpness of thought, closely relate to the objectives of learning mathematics: Promote students' strategic competence.

### **Mathematics learning with *das-dasan* games**

Before the *das-dasan* game begins, students make suits ([Figure 2](#)). It allows the player who wins the suit to start the *das-dasan* game. [Figure 3](#) shows students made observations on the game and exchange ideas to answer the task in the worksheet.

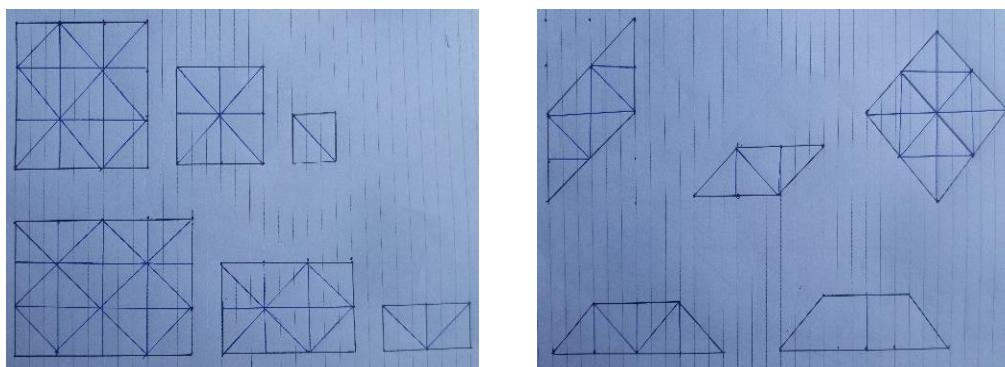


**Figure 2.** Students do a suit



**Figure 3.** Students discuss the worksheet

Figure 4 and Figure 5 shows one of the group works in identifying and determining rectangles and triangles. The first step taken by the group to find rectangles is to connect the intersection points of lines from one location to another. It was found several rectangles that could be formed by joining several points. The group determined the triangles by observing the *uwong* that is being carried out and linking the lines on the *das-dasan* game arena to form triangular patterns. The results of the triangles and rectangles vary, which indicate that *das-dasan* game promotes students' learning on the topic.



**Figure 4.** Rectangles in the *das-dasan* game arena

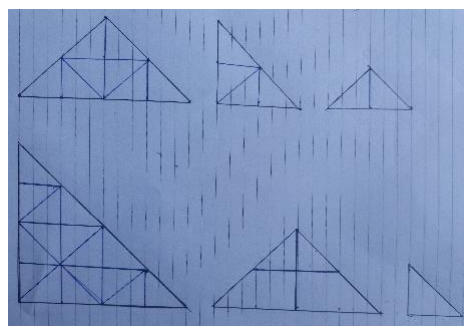


Figure 5. Triangles in the *das-dasan* game arena

### Students' mathematical strategic competence

The competence was measured using a test after two lessons with *das-dasan* games. Table 4 shows students' scores on the test. There are 15 students (coded as KSM) who achieved all indicators. Meanwhile, 5 students (coded as TSM) fulfilled M1 (formulating the problem) but had not fully completed M2 (representing the problem) and M3 (solving the problem).

Table 4. Students' score in the test

Interval	Frequency	Percentage (%)	Category
24 – 31	15	75	Very good
16 – 23	5	25	Good
8 – 15	0	0	Enough
0 – 7	0	0	Less
Total	20	100	
Average	25,5	Very good	

In Figure 6, KSM student correctly formulated the problem (M1). He understood the given problem and found the base and height of the plane by adding up the known ranges of the 7 cm square. Also, he represented the problem (M2) by drawing a parallelogram and its size. Next, students solve the problem (M3) by using the formula for the area of the parallelogram and find the correct result.

M1

M2

M3

(a) Banyak jajanan genjang

(b) Diketahui : Bangun berbentuk jajanan genjang  
 alas = 7 + 7 = 14 cm  
 tinggi = 7 + 7 = 14 cm  
 Ditanya : luas bangun jajanan genjang?  
 Dijawab :

Luas jajanan genjang = alas x tinggi  
 = 14 cm x 14 cm  
 = 196 cm<sup>2</sup>

∴ Jadi luas bangun yang terbentuk oleh uang (10) adalah 196 cm<sup>2</sup>

**Translation:**

(a) It is parallelogram

(b) *Given:* A parallelogram,  
 base = 7 + 7 = 14 cm  
 height = 7 + 7 = 14 cm  
*Question:* the area of parallelogram?

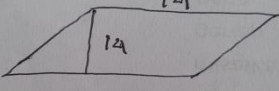
Area of parallelogram = base x height  
 = 14 cm x 14 cm  
 = 196 cm<sup>2</sup>

So, the area of the plane formed by Uwang (10) is 196 cm<sup>2</sup>

Figure 6. One of the KSM students' answer to the point (a) and (b) of the test



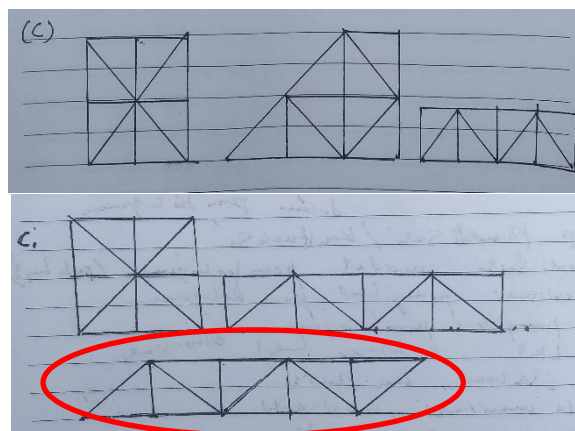
In Figure 7, a TSM student correctly formulated the problem (M1), which included three indicators: understanding the context of the problem, determining appropriate, and presenting the problem correctly. He found the base 14 cm long and 14 cm high but did not write down how to get the base and height. The student could not properly represent the problem (M2) as he drew a representation of the parallelogram that did not fit the arena of *das-dasan* game. Furthermore, he had not been able to choose and develop effective problem-solving methods due to the incomplete information about the unit of measurement and the area formula.

M1	a. Bangun Jajar genjang	<b>Translation:</b> a. It is parallelogram  b. Given: A parallelogram, $a = 14$ cm $t = 14$ cm   $L = 14 \times 14$ $= 196$ Area of the parallelogram = $196 \text{ cm}^2$
M2	b. Diketahui : bangun jajar genjang $a = 14$ cm $t = 14$ cm 	
M3	$L = 14 \times 14$ $= 196$ Luas jajargenjang = $196 \text{ cm}^2$	

**Figure 7.** One of the TSM students’ answer to the point (a) and (b) of the test

Figure 8 shows KSM (top) and TSM (bottom) student’s answer to point (c) of the test. KSM student made a new quadrilateral by combining eight right triangles that form a parallelogram. Furthermore, from the mixed results of the eight triangles, an examination is conducted to ensure the rectangular shape found in the *das-dasan* game arena. This reveals that KSM students could formulate the problem, represent the problem by combining small triangles to form square, trapezoid and rectangle, and answer the question. The TSM student in made quadrilateral as KSM student did. However, when determining the third plane, he was less careful and thorough because he did not re-check the planes made so that the ways are not in the *das-dasan* game arena. He was only able to formulate and represent the problem but had not yet been able to solve the problem correctly.

The represented KSM student’s work (Figure 6 and Figure 8) and our observation while he was working on the test unravel that the student was able to quickly formulated the problem by understanding the test questions first, then look for keywords to solve the problem by making *uwong* to connect from one point to another and small triangles to form the desired rectangles. Furthermore, he represented quadrilateral shapes and found the relationship between these shapes and the test questions to be completed. The student was precise in choosing the method of solving the problem. This finding, as the previous ones (Fouze & Amit, 2018; Nkopodi & Mosimege, 2009; Tatira et al., 2012), indicates that the use of cultural-based learning activities supports students construct mathematical knowledge. In addition, learning mathematics using traditional games allows students to be actively involved in learning.



**Figure 8.** Two students' answers to point (c) of the test

On the other hand, the TSM student spent more time to understand the problem, improperly represented the problem, and had difficulty and was less precise in determining problem-solving strategies which affect the final result. We observed that the student experienced misconceptions shown in the results of drawing the ladder which is not in accordance with the estimation (length is more than height) and does not match the arena of the *das-dasan* game. Furthermore, he was inaccurate in writing the steps of problem-solving with words. Prior studies (Arifin & Surya, 2019; Sigit, Utami, & Prihatiningtyas, 2018) also show that students make errors in strategic competence since they are not able to understand the problem commands (concept errors), determine ideas to represent problems (principle errors), and be careful and precise in writing steps of problem-solving (procedural errors).

Despite the developed local game-based learning support the majority of students develop strategic competence, we argue that the two lessons are not representative enough to conclude the effectivity of the designed learning activities. In this case, it needs to be revised to address the students' need who have not achieved all indicators of strategic competence. Then, further empirical tryout involving more students and lessons is certainly required.

#### **D. Conclusion**

In this study, we developed local game-based mathematics learning to develop students' strategic competence in learning the topic of rectangle and triangle. This game can be done practically since the tools and materials used are easily found in the school environment. The test shows that most of the students are able to formulate, represent, and solve triangle and rectangle problem embedding in the context of *das-dasan* game. However, several students are struggled with determining the mathematical ideas in the play of the game and choosing an appropriate strategy to solve the problem in the test which hamper their ability in solving the problem. We identified errors in determining the concept, principle, and procedure as the sources of the students' difficulty in accomplishing the last two parts of strategic competence.

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