Realistic Mathematics Learning in *Joglo* Traditional House Culture to Teach the Concept of Surface Area Constructing Space

Fransiska Duitasari Wijayanti Santoso[1*] and Hongki Julie[2]

[1] Sanata Dharma University Yogyakarta, Yogyakarta, Indonesia
[2] Sanata Dharma University Yogyakarta, Yogyakarta, Indonesia
*duitasarifransiska2@gmail.com

Abstract. Mathematics learning can be meaningful if presented in the context of real-life problems so that students can understand its applications. Realistic Mathematics Education (RME) is a learning approach that emphasizes the use of realistic contexts and situations to teach mathematical concepts and problem-solving skills. The purpose of this study is to introduce the culture of the *Joglo* Traditional House to students to teach the concept of the surface area of geometric shapes with RME. The subjects of the study are 9 students in grade 10 in Yogyakarta. Data collection techniques will be carried out through observation, written tests, and interviews. The research method is design research with qualitative data analysis. Based on the analysis, we can see six fundamental mathematical activities according to Bishop that provide a comprehensive framework for mathematics education in the cultural context of the *Joglo* Traditional House, namely: counting, measuring, locating, designing, playing, and explaining. The use of the *Joglo* Traditional House as a context can help students understand the concept of the surface area of geometric shapes. The implication of this research is to understand the process of constructing students' understanding through RME and to provide a reference for teachers to teach mathematics according to context.
CCS CONCEPTS • Learning • Innovation • Evaluation

Keywords: RME, Realistic Mathematics, *Joglo* Traditional House, Surface Area.

1 Introduction

Culture is something that cannot be separated from human life. This is because humans as social beings have their way of adapting to their groups. In this case, mathematics is also one of the concepts that are influenced by culture. Mathematics has become a basic capital for life, particularly for solving everyday problems [1]. However, nowadays in the globalization era, many students are not interested in learning Mathematics as well their own culture because they think Mathematics is hard, complicated, and usually taught by using traditional teaching. Students don't realize the importance of this subject. Mathematics is all around us and we have mathematics

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because mathematics is present in almost all human activities, for example, the use of numbers to represent house numbers, queues, or identifying shapes to represent and name an object. Likewise in cultures such as Indonesia which has various elements and local cultural values. Through this fact, teachers are expected to be able to teach Mathematics using the local cultural context. Context plays an important role in stimulating students to solve math problems. The context of mathematical activities is designed to enable students to construct their knowledge of mathematics. School Mathematics Curriculum (BNSP, 2006) suggests that mathematics substances should be presented in a contextual situation, which is proceeded by providing a contextual problem, and afterward, students are gradually guided to comprehend the concept and to communicate it respectively [2]. The approach to mathematics with real-life contexts is better known as Realistic Mathematics Education (RME). This encourages students to more easily practice the knowledge that will be obtained [3]. Realistic mathematics is very centered on the creative side of students. This emphasis forces students to innovate in gaining more realistic knowledge than just listening to information from the teacher. RME brings students to the real world of everyday experience, so that lessons learned in the mathematics classroom are not separate from the everyday life of students [4]. Ethnomathematics is the way in which people of diverse cultures use mathematics in everyday life [5]. By integrating culture and Mathematics into learning, students are expected to be able to know the diverse Indonesian culture and eventually develop a sense of love for this culture. This will lead to the character of discipline, creativity, and curiosity that mathematics is very close to real life and is no longer an abstract thing that is difficult to understand. The development of a mathematical learning model insight-oriented, problem-solving, and based on the local culture also managed to enrich students' knowledge of mathematics, enabling students to face global challenges, and also closer to the students' culture [6].

Gravemeijer (2001) proposed three main principles for realistic mathematics learning, namely guided reinvention or progressive mathematization, didactic phenomenology, and self-developed models [7]. There is a link between realistic learning and the process of learning mathematics such as how progressive mathematics requires interaction between students. Here the use of the local cultural context becomes relevant. Ambrosia (1985) made research that integrated culture as a context for learning mathematics. It was found that local cultural elements that can be linked to realistic mathematics learning are language, knowledge, technology, equipment, art, livelihoods, religion, relatives, customs, traditional buildings, and community organizations [8].

In research conducted by Saragih (2017) which aims to develop a student-centered learning model, the use of local culture-based models is effective for teaching and learning mathematics for junior high school students [9]. Based on the results and discussion of the research by Sulistyani (2019), regarding the *Joglo* traditional house, it can be concluded that the results of the study show that the culture of the *Joglo* Tulungagung traditional house has two-dimensional (2D) and three-dimensional (3D) elements contained in mathematical concepts [10]. Without understanding mathematical concepts, the Tulungagung people have applied mathematical concepts, so that it is proven that there is ethnomathematics in the *Joglo* Tulungagung

traditional house which can be seen in the architecture of the building and the carvings on the *gebyok* of the *Joglo* house. This shows that learning resources are not only in textbooks but can also come from the environment and also the culture around students. Learning mathematics with a cultural approach will be more meaningful for students. The results of another study from Kholisa (2021) concerning ethnomathematics exploration of the concept of geometry at the *Joglo* Pati House can be used as an alternative idea for learning mathematics outside the classroom related to regional culture. The results show that students can improve their ability to understand geometric concepts and increase their love for the culture of Rumah *Joglo* Pati [11]. Based on the results of interviews with teachers in the field regarding learning using a cultural context, information was obtained that the teacher had not taught Mathematics using a local cultural context in Yogyakarta because the teacher focused on the content. In addition to that, the teacher only used the example of the other problems but did not integrate it with culture. Based on the problems that have been encountered in the field and previous research, the objective of this study is to introduce the culture of the *Joglo* Traditional House to students to teach the concept of the surface area of geometric shapes using RME in grade X so that students will understand the meaningful Mathematics learning, preserve their culture and can enjoy learning Math. Through this study, the researcher also wants to analyze the fundamental mathematics activities according to Bishop in *Joglo* Traditional House Culture and understand the process of constructing students' understanding through RME. This research is in the phase of preparation and designing the lesson because it has not been implemented in the classroom yet.

1.1 Realistic Mathematics Education Approach

Definition of Realistic Mathematics Education. Realistic Mathematics Education has its underlying foundations in Hans Freudenthal's understanding of mathematics as a human activity [12]. Based on this thought, RME has a special characteristic, namely that in the learning process, students must be given the opportunity to reinvent mathematics through teacher guidance, and that the reinvention of mathematical ideas and concepts must start from exploring various situations and problems of the "real world". Modeling a real phenomenon that students can imagine, mathematically in the sense of looking for mathematics that is relevant to a phenomenon or constructing a mathematical concept of a phenomenon so that the learning process becomes meaningful [13]. Mathematical concepts emerge from the process of mathematization, which starts with context-linked solutions, students slowly develop mathematical tools and understanding to a more formal level. Models that emerge from students' mathematical activities will be able to encourage interaction in the classroom so that they lead to a higher level of mathematical thinking. RME is an innovative approach to learning mathematics that is in line with constructivism and contextual learning theory. Constructivism philosophy departs from Jean Piaget's theory which considers a person's cognitive structure as schemata, namely a collection of schemes. The scheme develops chronologically as a result of the interaction of the individual with his environment. According to constructivism, knowledge is a construction of people

who know schemata. Knowledge cannot be transferred from teacher to other people, because everyone has their own scheme of what they know. Constructivism can also be interpreted as a philosophy that considers knowledge as the result of human construction. Based on the constructivist paradigm, learning is an active activity where the students construct their knowledge by themselves [14]. Humans construct knowledge through interaction with objects, phenomena, experiences, and the environment [15]. RME is very closely related to contextual learning. Contextual learning is learning that relates learning material to the real-world context that students face every day both in the family, community, natural surroundings and the world of work, so that students are able to make connections between the knowledge they have and its application in everyday life. The foundation of the contextual learning philosophy is constructivism. So, it can be concluded that RME is a learning process that refers to student learning patterns that are active in constructing their knowledge through interaction with the environment, and by presenting contextual problems, students are brought towards progressive mathematization in a more abstract direction. This mathematization process will build students' mathematical concepts.

Characteristics of Realistic Mathematics Education. According to Gravemeijer, the five characteristics of PMR are as follows: (1) Use of context in the real world; (2) Mathematical ideas are constructed by students through vertical instrument models, which move from informal procedures to formal forms; (3) Students actively construct their own mathematical material problem-solving strategies with facilitation from the teacher, namely through a guided reinvention process; (4) Interactive activities between teachers and students in terms of guidance, as well as between students in terms of negotiating thoughts; (5) Problem-solving is not limited to a particular mathematical material, but is integrated with various related materials [16]. The characteristics of RME when viewed from learning theory and cognitive psychology according to Stillman et al. describe students who are solving problems as a psychological boundary between the comfort zone and risk-taking. Challenges teach students how to defend themselves in uncertainty, and skills relevant for lifelong learning and success with challenges preparing students for real life. So, it can be concluded that the characteristic of RME is the use of context in learning so that learning starts from real problems. Students construct conceptual understanding through real problems and are brought to more abstract concepts. The teacher's role is as a facilitator who guides students while still giving students the opportunity to think, interact, and solve problems independently.

1.2 The *Joglo* Traditional House

The *Joglo* Traditional House is one of the buildings with a traditional architectural style in Central Java. The *Joglo* house in the Javanese understanding is a reflection of the attitude, insight, and economic-socio-cultural level of the community. Thus, the house is like a person's lifestyle [17]. The arrangement of the rooms in the *Joglo* is divided into three main parts, the meeting room namely the *pendapa*, the middle room

which is called the *pringgitan*, and the back room namely *the dalem* which functions as a family room which the general public is not allowed to enter this area. Another room that is considered sacred and most private is *senthong*. There are three spatial structures*, left senthong, right senthong,* and *middle senthong*. The middle *senthong* is not used for the bed, but the right *senthong* is for the father's sleep in the west, and the east *senthong* is for the mother and immature children to sleep in the east [18]. The floor plan of the *Joglo* house has two typologies, rectangular and square shapes, this is adapted to the aesthetics of life of the Javanese people who have firm and responsible principles in living their lives [19]. Decorations on traditional Javanese buildings which are intended as symbols of guidance and demands of human life are mostly placed on a series of *saka guru* and intercropping beams [20]. The following are the pictures of the *Joglo* house plan [21]:

Fig. 1. Joglo house plan

Fig. 2. Joglo Traditional House, from https://id.theasianparent.com/

Joglo is a traditional Javanese house that is generally made of teak wood. The term *Joglo* refers to the shape of the roof, taking the philosophical form of a mountain. In the beginning, philosophically, the shape of the mountain was given the name roof *tajug*, then it developed into a roof *Joglo* (*tajug* loro means merging of two canopies). The *Joglo* house has a square roof on four sides, then the roof in the middle is shaped like a cone but not sharp. In general, the roof of the *Joglo* house consists of two parts, namely the roof frame and roof covering. The material generally used for the *Joglo* roof frame is wood, both plain wood and full of carvings, which are adjusted to the economic capacity of each occupant. While the roof covering material usually uses clay tiles and roof shingles. Clay tiles are made from clay which is pressed and then fired. The drawback of this tile is the occurrence of discoloration and the appearance of mold when it is used longer. The shingle roof is made of thin ironwood chips. The advantages of this roof covering are light, strong, and reflect heat so that it makes the room below cooler and makes the roof look more beautiful.

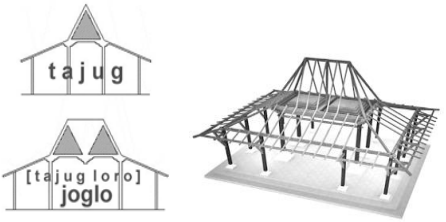

Fig. 3. The shape of the *tajug* roof of the *Joglo* house

The unique characteristic of the *Joglo* traditional house is the position of the main door. The *Joglo* house always places the main door in the middle as a symbol of openness and closeness between homeowners. There are also doors located on the right and left [22]. The position of these three doors depicts the symbol of a butterfly that continues to fly, grow, and strive for the big family. In traditional *Joglo* houses in ancient times, the walls, doors, and windows were made of wood.

2 Method

2.1 Types of Research

This type of research is design research. According to Plomp, design research is a systematic study of designing, developing, and evaluating educational interventions (such as programs, strategies, and learning materials) as solutions to solve complex problems in educational practice which also aims to advance knowledge [23] and improve the world of education. Akker argues that development research is circular research, twisting and turning in carrying out the steps of analysis, design, evaluation, and revision to achieve goals [24]. Design research is a method that has five forms, namely: (1) Interventionist nature, meaning a design research that has a flexible nature; (2) Process-oriented, in the form of a design based on learning planning and equipped with supporting tools or devices used during the learning process; (3) Reflective component is a research design that is compared with the actual learning process; (4) Cyclic character, evaluation of each cycle in the implementation of research and improvements will be made in further learning; (5) Theory oriented, the design is used through the application of theory and linking the theory with learning trials.

Design research is divided into three phases. The first phase is trial preparation, the second phase is trial design, and the third phase is retrospective analysis. This paper, only discusses the first phase of design research, namely trial preparation because it has not yet been applied in the classroom. This research uses design research because the researcher wants to try to apply existing theories about educational and teaching practices, especially by using a realistic mathematical approach in the cultural context of the *Joglo* house to develop the concept of geometric surface area, which can be implemented in the classroom. The researcher designs a learning material and creates a hypothetical learning trajectory (HLT). HLT is a theoretical framework that describes the expected sequence of learning objectives, concepts, and skills in a given

subject. After that, an analysis, reflection, and improvement of the existing findings will be carried out. This is done so that researchers can develop something that can provide benefits to the world of education.

2.2 Research Subjects

Research subjects are people, places, or objects that are observed in the context of machining as targets. The subjects in this study are 9 students of grade X from Private Senior High School in Yogyakarta.

2.3 Research Object

The object of research is a set of elements that can be in the form of people, organizations or goods to be studied. The research object can be said to be studied in order to obtain data in a more directed manner. In this study, the object of research is the fundamental mathematical activity of the study of the *Joglo* traditional house.

2.4 Data Collection Methods and Instruments

Data collection was carried out by studying the literature and looking for theories that were in accordance with the *Joglo* house and RME as well as looking for studies on *Joglo* houses that had been done before. This is done to get information about the shape of the roof and floor plan of the *Joglo* house to create problems and to find the right topics in Mathematics that can be taught using the *Joglo* house concept. In addition, data collection was carried out by observing examples of parts of the *Joglo* house in the Yogyakarta Palace as material for making Mathematical problems in HLT. Additional tools that support information retrieval, such as cameras, cell phones for recorders, pencils, ballpoint pens, books, and laptops. The research instruments that will be used are observation, written tests, and interviews.

2.5 Data analysis technique

Data analysis techniques using qualitative data analysis. Qualitative research is denoted as consisting of the basic empirical material, collected in the research process, which is verbally described or narrated [25]. In qualitative research, problem analysis, factor analysis, and theory development are the main characteristics [26]. One of the reasons for using a qualitative approach is that qualitative research is elaborative in nature and can help researchers to dig up more detailed and in-depth information regarding a phenomenon that occurs. The activity in data analysis in question is data reduction; data display; and conclusion drawing. The data to be analyzed is the fundamental mathematical activity of the study of the culture of the *Joglo* traditional house, especially in terms of the parts of the *Joglo* house and the shape of the roof. In addition, the thing that will be analyzed is the HLT (hypothetical learning trajectory) which has been created in terms of the sequence of problems, how the progressive

process of mathematics occurs based on the RME character, the supports given, the interactions that are built between subjects in learning.

3 Result and Discussion

3.1 Analysis of Mathematical Fundamental Activities from Cultural Studies

The Mathematical Fundamental Analysis of the *Joglo* house can be explained as follows. Counting activities can be seen in the number of rooms in the *Joglo*. The floor plan of the *Joglo* house is divided into three main rooms, namely the *"pendhapa, pringgitan and omah njero".* Counting activities can also be seen from the activity of calculating the surface area of the walls and roof of the *Joglo* house and calculating the number of doors and windows needed in the *Joglo* house. This is important when someone is going to build a *Joglo* house. Measuring activities can be seen from the area and comparison of the size of each part of the room. This activity can also be seen when measuring the *Joglo* house in the *Dalem Ageng* section or other parts using units of measurement. Locating activities can be seen from the placement of the rooms in the *Joglo* house. The location of the *pendapa* is always in the front, *Dalem Ageng* room is in the middle and the kitchen is at the back. Designing activities can be seen from observing the shape of the roof of the *Joglo tajug* house (similar to a conical pyramidal roof). Playing activities can be seen from the rules in the use of the room, such as the *middle senthong* may not be used as a bed. Left and right *senthong* are used for beds. Explanation activities can be seen by examining the meaning of each room in the *Joglo* house starting from the *pendhapa* is the part of the *Joglo* which is commonly used for entertaining guests, a place for holding meetings, parties, or performances. Sometimes, this room is even used as a gamelan venue. The open structure of the *pendhapa* means that the Javanese are open and friendly. Meanwhile, the *pringgitan* is a room used as an introduction before entering the *Dalem Ageng* which is the center of the Javanese house, and the part of the living room is also used to receive guests who have a closer relationship with the owner of the house. So, we can see the 6 Fundamental Mathematics in the context of *Joglo* Traditional House according to Bishop that provides a comprehensive framework for mathematics education.

3.2 Hypothetical Learning Trajectory Analysis

The following are the problems based on HLT (Hypothetical Learning Trajectory). HLT is divided into two meetings. There were four problems at the first meeting and three problems at the second meeting.

Problem sequence. The sequence of problems in this HLT includes: (1) Finding the area of the door in the *Joglo* house based on observation; (2) Calculating the area of all doors and windows; (3) Calculating the surface area of the *Joglo* house walls; (4) Calculating the cost of buying wood for the walls, doors, and windows of a *Joglo*

house; (5) Finding the area of the combined flat wake from the cross-section of the roof in the form of two trapezoids; (6) Finding the area of the combined plane shape from the cross-section of the roof in the form of a triangle and a trapezoid; (7) Finding the surface area of the *Joglo* roof which is irregularly shaped combined with Pythagoras' theorem method. The context of the problem regarding the *Joglo* house shown is quite easy for students to understand because the issues raised are about the shape of the walls, roof, and the use of each part of the room in the *Joglo* house. Here are the pictures of the problems [27].

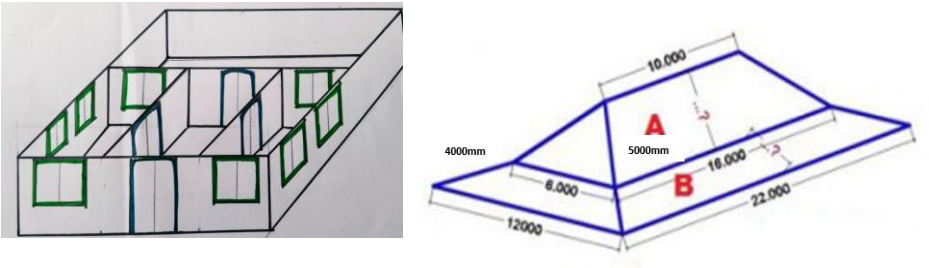

Fig. 4. *Joglo* wall and roof problems in HLT

Problems start with real-life problems from simple things around them, calculate the area of windows, doors, walls, and roofs. This can help students to think more realistically and attract students' curiosity to learn Mathematics. The terms in the room of the *Joglo* house are indeed quite complicated, for example, *pendhapa, dalem ageng, senthong,* etc. However, it is this cultural element that will be introduced to students so that nowadays students still understand the terms part of the room in a traditional *Joglo* house in Javanese and they can continue to preserve the culture of the *Joglo* house in the future.

Mathematical progressive process. In the HLT, the problems presented show an improvement from a simple concept starting with calculating the area of one flat shape, namely a rectangular door, followed by finding the combined area of two different flat shapes with doors and windows. Then proceed with the surface area of a regular geometric shape, namely the surface area of a wall that resembles a beam. After that, students use the concept of the area of a flat shape in calculating the area of a trapezoidal and triangular roof using the Pythagorean concept. In the end, students are brought to gain a more complex understanding by calculating the surface area of the *Joglo* roof which is an irregular geometric shape. The problems presented are good for building students' concepts about the surface area of geometric shapes. This can be illustrated by the Iceberg model for the RME approach in Figure 6 below, through real problems, students are directed to solve them using mathematical concepts so that students can build their knowledge. When students understand mathematical concepts in simple real-life problem-solving, students can think more abstractly in solving more complex mathematical problems by using mathematical symbols.

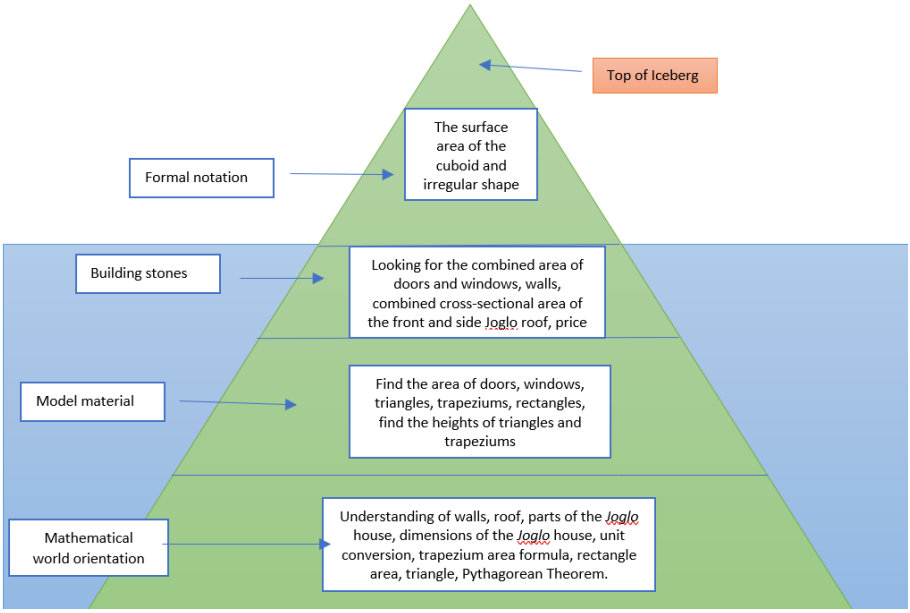

Fig. 5. Iceberg in constructing the surface area concept of geometric shapes

Developed Interaction Process. The interaction process that has been developed is good because there is two-way interaction and communication between teachers and students in learning. This can be seen when the teacher presents a problem about the parts of the *Joglo* house at the beginning of the meeting and asks students to calculate the area of the door, and the cost of a wooden *gebyok* for the *Joglo* house. The teacher provides support to students when solving problems such as some questions that guide the students to find the answer but not directly giving the answers. Students respond and answer the teacher's support until they can find answers to their problems. The teacher also gives students the opportunity to work in groups to solve problems together to find the surface area of the roof of the *Joglo*. It will train students to argue in express their ideas.

3.3 Linking research results with the theory that was built.

Realistic Mathematics Learning (RME) can use cultural elements of the traditional *Joglo* house as a context for learning the concept of the surface area of geometric shapes. This is in accordance with Freudenthal's opinion about the use of realistic concepts. The use of traditional *Joglo* traditional houses presents new cultural and contextual information. Exploring the philosophical elements in the house of Javanese tradition opens up the minds of the younger generation as heirs of culture in the future to maintain and preserve the legacy of its predecessors [28]. In accordance with constructivism, students are expected to see mathematical concepts that can be built from various kinds of objects and also personal experiences so they can build their own

concepts about the surface area of a geometric shape. Learning begins with presenting contextual problems about the *Joglo* house and its philosophy. Students can certainly imagine the shape of a house because they see every day the structure of the house, the walls, windows, and roof. From this real problem, students can construct their understanding to find the area of a door, window, wall, or roof surface. Mathematics learning that makes use of the environment is intended to generate thoughts and give students the greatest possible opportunity to understand mathematical material [29]. In addition to that, students get the opportunity to be able to discuss in groups. Students argue and present the results. This is in accordance with the characteristics of RME according to Gravemeijer, the principle of realistic mathematics learning is an interactive mathematics learning process.

4 Conclusion

Learning Realistic Mathematics by using the cultural object of the *Joglo* Traditional House as a context can help students learn and understand the concept of the surface area of a geometric shape. Students construct their understanding through realistic problems of calculating the area of windows, doors, walls, and roofs followed by an abstract problem to find the surface area of irregular shapes. Presenting simple problems followed by more complex problems in a systematic way can construct students' understanding of finding the surface area of rectangular and irregular geometric shapes. In addition to that, we can also see the six fundamental mathematical activities according to Bishop in the cultural context of the *Joglo* Traditional House, namely: counting, measuring, locating, designing, playing, and explaining. The implication of this research is to provide a reference for teachers to teach mathematics according to context, especially *Joglo* Traditional House culture and to understand the process of constructing students' understanding through RME, so learning Mathematics can be more meaningful for students. The researcher recommends that educators or teachers use another Traditional House Culture to teach Math based on their own location and culture so that the learning will be really contextual and students can have more understanding.

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