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Supporting 7th Grade Students' Understanding of Angles using Central Java Traditional House

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Abstract

Angle is one of the important materials to be studied because it is basic in learning geometry and many applications in life. However, students still have difficulty in learning angles. Therefore, it is necessary to design learning with the right context and approach to overcome the difficulties. This study aims to produce a learning trajectory that will help students for understanding angles. The activities were designed based on IRME with Joglo Traditional house context as the starting point. A design research method is used has three stages: preparing for the experiment, design experiment, and retrospective analysis. This study's subjects were 6 students from SMP Negeri 1 Juwana with different abilities: high, medium, and low abilities. The result of this study was Learning Trajectory which consists of learning processes in four activities: observing the video of the joglo traditional house for understanding the concept of angles, drawing and measuring the angles; categorizing the angles types; solve contextual problems related to angles. In this study, the design experiment stage was limited to the pilot experiment stage. This study shows that learning design using the context of a traditional house can help students to understand the angle and can be an inspiration to explore local wisdom to introduce mathematics topics.

Abstrak

Sudut merupakan salah satu materi yang penting dipelajari karena merupakan dasar dalam pembelajaran geometri dan juga banyak aplikasinya dalam kehidupan. Namun, siswa masih mengalami kesulitan dalam mempelajari sudut. Oleh karena itu, perlu dirancang pembelajaran sudut dengan konteks dan pendekatan yang tepat untuk mengatasi kesulitan tersebut. Penelitian ini bertujuan menghasilkan lintasan belajar yang membantu siswa dalam memahami sudut. Semua kegiatan didesain berbasis PMRI dengan konteks rumah adat joglo sebagai starting point*. Metode design research digunakan terdiri dari tiga tahapan yaitu preparing for the experiment, design experiment, dan retrospective analysis. Subjek dari penelitian ini adalah 6 siswa dari SMP Negeri 1 Juwana dengan kemampuan yang berbeda yaitu kemampuan tinggi, sedang, dan rendah. Hasil dari penelitian adalah lintasan belajar yang terdiri dari serangkaian proses pembelajaran dalam empat aktivitas yaitu mengamati video rumah adat joglo untuk memahami konsep sudut, menggambar dan mengukur besar sudut; mengkategorikan jenis-jenis sudut; dan menyelesaikan masalah kontekstual yang berkaitan dengan sudut. Pada penelitian ini, tahapan design experiment hanya terbatas tahap ujicoba pilot. Penelitian ini menunjukkan bahwa pembelajaran dengan konteks rumah adat membantu siswa untuk memahami sudut dan dapat menjadi inspirasi untuk menggali kearifan lokal untuk memperkenalkan topik matematika.*

Keywords*: Design research; Angles; IRME; Joglo Traditional House.*

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BACKGROUND

Angles are important for students to study (Widyawati et al., 2016). In addition, angles are the basis for studying geometry (Leone, 2008). Angles are widely applied in various fields of life such as physics, architecture, and even astronomy (Machisi & Ogbonnaya, 2014). This is also complemented by Susilowati (2017) who stated that angles are important to study because they have many applications in life such as carpentry, transportation, and others. From the explanation above, it can be concluded that angles are very important for students to study.

Despite the importance of angles to be studied, there are still many students who have difficulties in learning angles such as difficulty in measuring certain angles such as 00, 1800, and 3600 (Keizer, 2004). In addition, students also still have difficulty in distinguishing the types of angles and determining the measure of the angles because students are less motivated (Safitri, 2012). Then, according to Argaswari & Usodo (2015), another student's difficulty is determining the measure of angles that are connected to the concept of lines. The same thing is conveyed by Sari et al. (2015), that students still do not understand the concept of angle measurement. Misunderstanding of the angle measurement concept can be in the form of misunderstanding of students who think that the length of rays that form an angle affects the measurement of angles (Lehrer in Sari et al., 2015). A study from Senjaya et al., (2017) revealed that there are several students' difficulties in learning angles such as students not understanding questions given, not understanding concepts, students are not being careful in writing symbols, and not being careful in math calculations.

The difficulty of understanding angles, especially at the junior high school level, is students have not been able to understand length and angles (Mitchelmore & White, 1995). In addition, according to Oktaviana, students' learning difficulties in angles are caused because teachers prefer to do procedural learning (Widyawati et al., 2016). Procedural learning that is usually carried out by teachers is limited to explaining the material then providing examples and giving exercises (Soedjadi, 2020). Procedural learning causes passive learning without allowing students to construct their knowledge and find their concepts. In this case, student-oriented learning is needed to facilitate students in constructing their knowledge and participating actively in learning (Kusumaningsih et al., 2020).

To overcome the causes of learning difficulties that have been described above, the teacher can design or prepare the learning with an approach or method that is suitable to the characteristics of students and the material by using a context that is familiar or can be imagined by students so that learning becomes conducive and learning goal is achieved. One of the effective approaches that can be used in mathematics learning is the Indonesian Realistic Mathematics Education (IRME) (Widiawati. et al., 2018; Wahidin & Sugiman, 2014).

IRME is a learning theory where real things become a starting point and emphasize the ability of process skills such as the ability to discuss and argue and be able to construct their understanding so that they can solve problems well (Zulkardi & Putri, 2010). Hadi said that IRME is an approach that is oriented towards the application of mathematics in daily life (Widyawati et al., 2016). The IRME approach is a student-centered learning approach and the teacher only as

a facilitator, besides that this approach is chosen because this approach is oriented to the mathematization of daily experiences and applying mathematics in daily life. In the learning process of IRME, students are allowed to discover mathematics through teacher guidance (Gravemeijer, 1994). Indonesian Realistic Mathematics Education (IRME) emphasizes learning mathematics starting from things that are close or real for students. Therefore, learning becomes more meaningful for students (Widyawati et al., 2016). According to Freudenthal (Yuniarti, 2016), the special characteristics of IRME lie in three main principles, namely 1) Guided Reinvention and Progressive Mathematization: the learning does not begin with definitions, properties, or theorems but instead begins with realistic contextual problems. Furthermore, through designed activities, students are expected to be able to rediscover understanding of definitions, mathematical properties (theorems), etc. In addition, the Progressive Mathematization Principle emphasizes "mathematization", which can be interpreted as an effort to lead to mathematical thinking. 2) Didactical Phenomenology: This principle emphasizes the importance of contextual problems to introduce mathematical topics to students and emphasizes meaningful learning experiences. 3) Self-Developed Models: students have the freedom to develop models that come from contextual problems and will go to formal mathematics. The model may still be simple (informal) and still like the contextual problem (model of) and students are expected to be able to develop a model that leads to formal mathematics (model for). From the explanation above, IRME shows that it is not learning that tends to be procedural.

The application of IRME emphasizes the usefulness of concepts that can increase motivation and interest in learning and can be a bridge for students from the real stage to the formal stage (Sari et al., 2015; Lestari, Nugroho, & Nursyahidah, 2021). Learning using IRME starts from the use of context which is the starting point to the development of understanding in mathematics (Nursyahidah et al., 2021) and also as a source of learning (Widiawati. et al., 2018) that can facilitate students from the informal stage to the formal mathematics stage (Nursyahidah et al., 2021). In mathematics learning, many contexts have been used as starting points and learning resources. For the angles material, several contexts have been used such as the context of the reed fence (Widiawati et al., 2018), the context of the tin museum (Apriani & Agustine, 2019), the context of the Limas Traditional House (Widyawati et al., 2016), the context of climbing (Fyhn, 2008), the context of rats and cats (Bustang et al., 2013) and the context of the solar system (Sari, Putri, Kesumawati, 2015). This study used the context of the Central Java Traditional House for angle learning, that is Joglo. The Joglo Traditional House can be used as a context for angles material because many angles concepts can be found in the Joglo Traditional House and which are not only as a starting point and a source of learning but also as an effort to introduce local wisdom in Indonesia to students, especially from Central Java.

Some previous research stated that learning or developing IRME-based learning materials can facilitate students in communicating mathematically in learning (Rohati, 2015), and also students are motivated and creative so that understanding of the concept can be achieved (Sunismi, 2015; Simanulang, 2014; Fitri & Prahmana, 2018). In addition, IRME-based learning can increase student motivation and ability to solve given problems

(Nursyahidah et al., 2020; Fahrurozi et al., 2018; Nuraini, 2019) and also give help for the students to stimulate student's understanding (Nursyahidah et al., 2020). Therefore, this study would like to design the learning trajectory that will help seventh-grade students for understanding angles using Central Java Traditional House.

METHOD

This study used the design research method validation type which is used to try out the HLT to small groups of students in proving the theory in cycle 1 learning. The data from HLT testing is revised and used in the teaching experiment stage (Nieveen, McKenney & Akker, 2006). This study was conducted at SMP Negeri 1 Juwana from January to February 2021. The subjects of this study were 6 students with different abilities: high, moderate, and low abilities. The determination of student's ability is based on the score of the students and the recommendation of the teacher. According to Gravemeijer & Cobb (2006), three stages of design research, namely I) Preparing for the experiment. There are several activities carried out such as conducting literature reviews, designing HLT with a series of IRME-based activities, designing learning instruments. II) Design experiment. The activities carried out were: 1) pilot experiment, namely HLT testing to small groups of 6 students into 3 groups with different abilities: high, medium, and low abilities, 2) Teaching experiment, HLT that was tested in the pilot experiment was repaired and revised then tried out back to the class. III) Retrospective Analysis: analyzing the data obtained in the teaching experiment stage then developing designs for further learning activities. Furthermore, comparing HLT with actual learning activities to answer the problem formulation and study objectives. The main instrument of this study is the HLT which is a series of learning processes consisting of learning objectives, activities (what to do and use in learning), and the thinking conjecture of students. This HLT is used as a guide of learning and as the basis and focus of study in analyzing data, namely comparing actual learning and HLT so that it produces a learning trajectory that can be used in learning. There are several activities in data collection, namely observation, recordings of class activities, students' work, results of pretest and posttests, and interviews. Data collected is used to find out the real situation in learning. All data obtained were then analyzed to improve further activities.

In this study, researchers only researched up to the pilot experiment stage (of the design experiment) due to the limitations of researchers during the Covid-19 pandemic.

RESULT AND DISCUSSION

Result

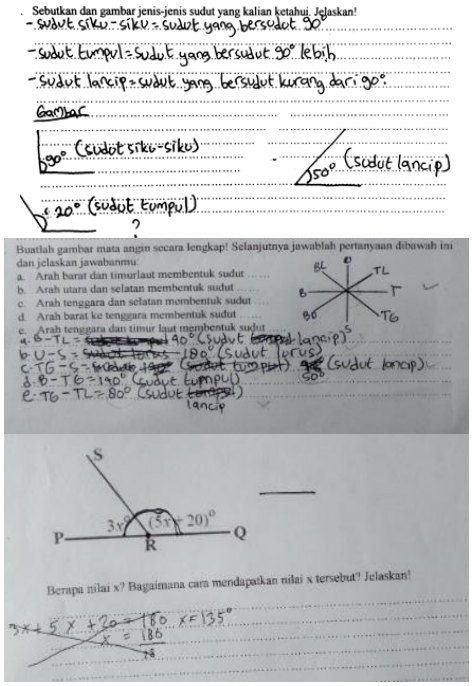
HLT which consists of a series of learning processes and activities has been designed by researchers to facilitate students' understanding of angles based on the Indonesian Realistic Mathematics Education (IRME) by using the context of the Joglo Traditional House. Literature reviews and discussions with teachers and lecturers were carried out to make predictions of the expected learning trajectory. The actual learning is expected to be following with the HLT that has been designed, and the design of HLT can be used as anticipation of possible possibilities that occur during the learning process. HLT designed will be explained in the table 1.

Table 1. Learning Process

Activity	Conjecture
Observing context video to understand angle's concept Paint and measure the angles	• Student can find the concept of angles by observing context video and CCTV working system • Students can identify 3 angles from the context and then construct them from informal to formal mathematics • Students can determine the measure of the angle from angle given by measuring it using a protractor and communicating the steps of measuring it • Students can find the concept of the type of angles (acute, obtuse, right angle) by constructing the angles given according to activity sheet instruction and can mention the angle measure correctly and define the types of angles well. • students are also possible to understand complementary and supplementary angles
Categorizing the angle types	• Students can categorize the type of angles well
Solving the problem related to angles	• Students solve problems related to angles using the knowledge gained in the previous activity.

After the preparing for the experiment stage has been carried out, the next step is to conduct HLT testing for small groups that consist of 6 students divided into 3 groups, namely groups of students with high, medium, and low abilities. Before and after learning, students are given a pre-test and post-test to determine the level of understanding of students at the beginning and the end of learning. Pre-test dan Post-test adjusted to the learning objectives to be achieved.

Pre-test



Translation:

Name and draw the angles that you know!

Right angle: an angle that measures 90°
Obtuse angle: an angle that measures more than 90°
Acute angle: an angle that measures less than 90°

Draw the compass completely! Answer the questions and give your explanation!

west-northeast = 40° (an acute angle)
north-south = 180° (straight angle)
southeast-south = 50° (an acute angle)
west-southeast = 140° (obtuse angle)
southeast-northeast = 80° (an acute angle)

Figure 1. student's work on pre-test

The pre-test was carried out before the activities that have been previously designed are tested on students consisting of formal mathematics questions. The purpose of giving a pre-test is to determine the students' initial abilities and the pretest result is used as the basis for designing activities that will be tested on students such as emphasizing parts that students have not understood. In addition, the results of the pretest will also be compared to the results of the post-test to

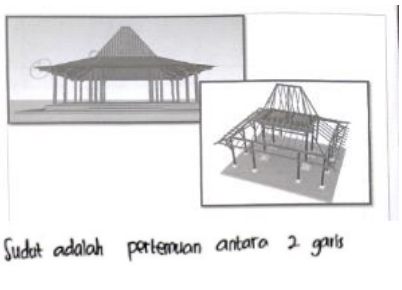
determine students' understanding before and after the activities.

Based on figure 1, some things can be found in student's work. The students are not correct in determining the angles from the compass and not correct in mentioning the measure of obtuse angles and acute angles and students do not understand the concept of the supplementary angles so that students have not been able to solve the problems given. This mistake is due to the students' lack of conceptual understanding. Therefore, it is necessary to design activities that can facilitate students in understanding the concept of the material well.

Activity 1: Observing context video for understanding angle's concept

This activity begins with students observing the video of the context of the Joglo Traditional House as a starting point to understand the concept of angles that previously students saw problems on the activity sheet given first. The teacher provides context videos and pictures that are as real as possible so that students can explore the context thoroughly and get informal information to learn lines and angles material. Students explore the context of the Joglo traditional house starting from observing the shape of the building, the part of the building, the framework of the building to the philosophy of the building for providing complete information to recognize and understand angles. By looking at the context students can find angles and construct knowledge from the video to understand the concepts of angles. In addition, by observing video of the context and being given the help of context pictures on the activity sheet, students can define the concept of angle. Students defined that "angle is the meeting/intersecting of two lines". This corresponds to the conjecture on the HLT.

The student's work can be seen in Figure 2.



Translation:

An angle is the intersection of two lines

Figure 2. student's work on activity 1

Because observing the context has not provided a complete understanding, the researcher provides problems regarding how CCTV works which is still related to the context used, Joglo traditional house. By understanding how CCTV works, it is hoped that following the conjecture of researchers, students can understand the concept of angles more fully, such as understanding the angle area, rays, and vertex. On the activity sheet, students are asked to more understand the concept of angles through the CCTV working system that is installed in the joglo traditional house by imagining and providing vision limits and blind spots on CCTV. CCTV is an additional context that can still be related with the context used to provide facilities for students to understand the concept of angles properly and correctly the following are the results of student's work on activity 1:

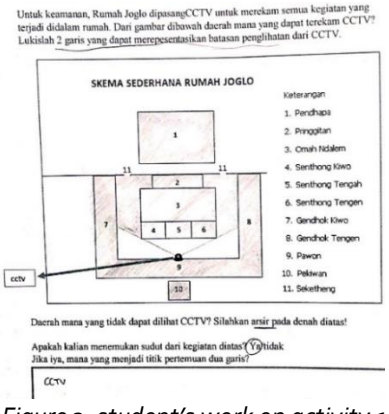


Figure 3. student's work on activity 1

The student's work in Figure 3 shows that students can determine the limits of vision from CCTV and determine which areas (blind spots) can be recorded by CCTV or not. Students can paint the limits of vision from CCTV and color the blind spot (areas that are not recorded by CCTV). From the limitations of CCTV vision, students are directed to understand the rays. Students are also able to know that CCTV and its vision limits can form an angle with CCTV as a vertex and the vision limit as arms. In every activity, the teacher always provides guidance and stimulus so that students are better able to explore the ideas they get. Students are also able to understand the concept of angles according to the discussion with the teacher such as students can show the area of angle correctly, can distinguish vertex and angles areas, and able to understand the line rays that form an angle. And in the end, students can find and understand the concept of angles well through exploration in the context of the joglo traditional house and the CCTV work system located in the traditional house. Students also improve the definition of angle "angle is an area formed from two rays that meet at a point called the vertex".

This activity is inspired by a study of (Bustang et al., 2013) which involves spatial representations that can be used to facilitate students' understanding of the concept of angle.

Activity 2: Paint and measure the angles

After understanding the concept of angle in the first activity through observing video/context pictures and how CCTV works, then students give activity sheet 2 with the aim that students can paint and determine the measure of the angle using a protractor. Activity 2 begins by finding and identifying 3 angles from the context with different angle measures, then constructing the three angles that have been found using a straw. After that, students are allowed to paint the three angles in a formal mathematical form according to the shape and measure of the angle found in the context.

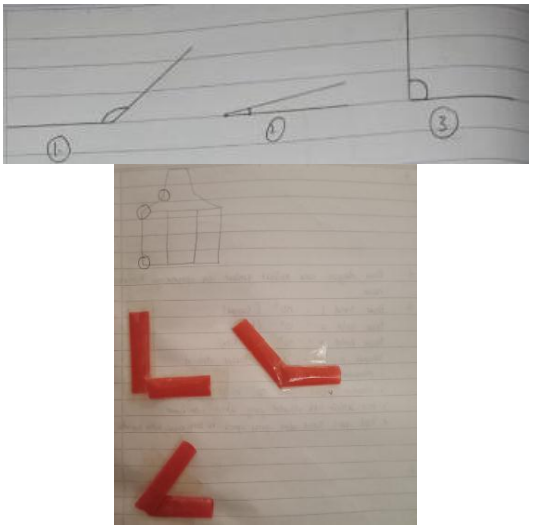
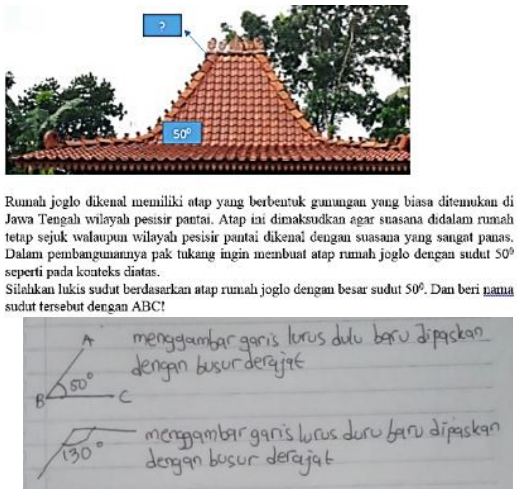


Figure 4. student's work on activity 2

Figure 4 shows that students can identify 3 angles that have different angle measures and can construct using straws according to the shape and measure of the angles found. This is what is meant by modeling from the information of the context and the model is still In an informal form, it is hoped that students will be constructing an informal form to formal form. That is following one of the IRME principles, namely Self-Developed Models (Freudenthal (Yuniarti, 2016)). In addition, students are also able to paint angles in the form of formal mathematics. What needs to be emphasized in this activity is the angle of the construction results using straw and the angle in the form of formal mathematics must have the same measurement because in student's work there are still deficiencies in that section. With teacher guidance through discussion, students can identify deficiencies in doing activity 2 and be able to fix them.

The activity is continued by measuring the angle that has been constructed using a protractor and students are asked to explain the process of measuring the angle using a protractor. Students can determine the measure of angles using a protractor well, but the steps for measuring angles written in the activity sheet are a bit unclear and confusing. After being confirmed in the discussion session between students and teacher, students can explain the steps of measuring angles well such as students mention the steps of measuring angles of 140 degrees "Draw straight lines first, continuing to mark at 140 degrees". Students also have ideas if determining the measure of angles with angles facing a different direction. According to the discussion, students mention that measuring the measure of angles can be done with one arm of the angle that must be straightened at a point of 0 degrees and the vertex is determined first, then the other arm of the angle shows the measure of the angle being measured.

Then, at the end of the activity students are given the roof of the joglo traditional house with its philosophy with an angle of the roof is 50° and another angle is unknown. Students are asked to paint the 50° angle and find the unknown angle by using a protractor. The student's work is shown in figure 5.



Translation:

FIGURE

Draw a straight line first then fit it with a protractor

FIGURE

Draw a straight line first then fit it with a protractor

Figure 5. student's work on activity 2

Figure 5 shows that students can paint angles from the angle given on the activity sheet and find the unknown angle measure. To find the measure of an unknown angle of the context, students have the idea, that idea is first constructing and painting an unknown angle in the context. After that, students measure the angle using a protractor properly. In addition, students can express the process of measuring angles using a protractor using their sentences. The teacher is only a guide and provides direction.

Activity 3: Categorizing the angle types

Activity 3 is categorizing the types of angles. Activity 3 does not only emphasize the types of angles but emphasizes more on understanding the measure of the angles in each type of angle, because of the results of the pre-test, students are still not precise in mentioning the measure of acute and obtuse angles. After students carry out activity 1 and activity 2, it is hoped that students will be able to complete activity 3 well. In activity 3, students are asked to identify 3 angles in the context with several conditions such as identifying angles that have angle measures of 90 degrees, less than 90 degrees, and more than 90 degrees which can be found in the context of the Joglo traditional house.

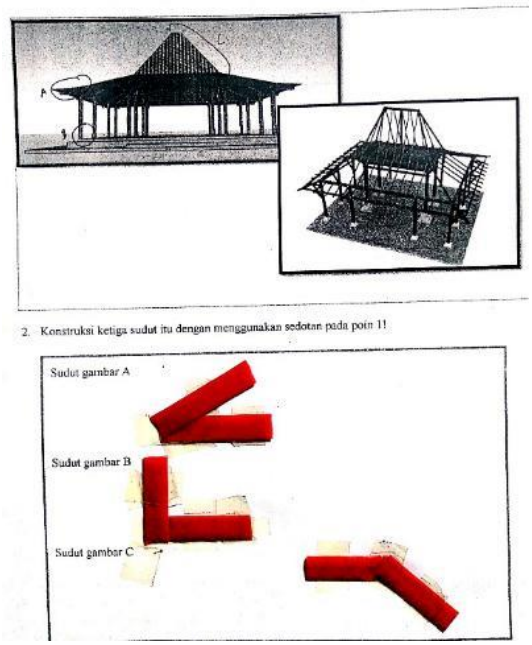
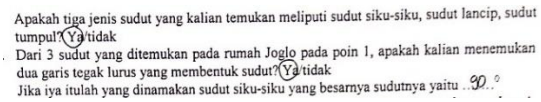


Figure 6. student's work on activity 3

Figure 6 shows that students can find 3 angles according to the conditions given previously in the context and can construct them using a straw to understand the measure of the angles of each type of angle well. Next, students construct and determine the measure of the angles from the 3 found angles. By looking at the context and initial knowledge, students can easily find the right angles and define them. This following the Figure 7.


Apakah tiga jenis sudut yang kalian temukan meliputi sudut siku-siku, sudut lancip, sudut tumpul? (Ya)/tidak
Dari 3 sudut yang ditemukan pada rumah Joglo pada poin 1, apakah kalian menemukan dua garis tegak lurus yang membentuk sudut? (Ya)/tidak
Jika iya itulah yang dinamakan sudut siku-siku yang besarnya sudutnya yaitu ..90..°

Translation:

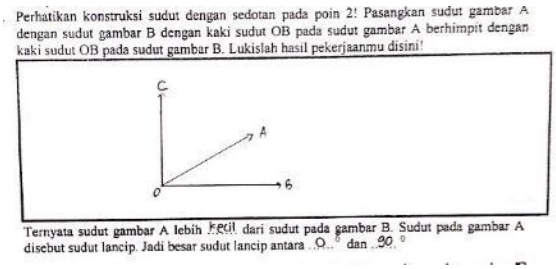
From the three angles that you found in the joglo traditional house, did you find two perpendicular lines that formed an angle? Yes

if yes, what is the measure of the angle? 90°

Figure 7. student's work on activity 3

On the student's work above, students easily find right angles in the context of the Joglo Traditional House and can define it well based on observations of the context and also previous knowledge about right angles.

Furthermore, students are asked to construct two angles given by combining these two angles to define and determine the measurement of acute and obtuse angles well. Student's work can be explained as follows:



Translation:

Pay attention to the angles construction that you have made. Match the angle of picture A with the angle of picture B with the arm OB on the angle of picture A coincide with the arm OB on picture B. Paint your work!

FIGURE

It shows that the angle of picture A is smaller than the angle of picture B. Angle A is called an acute angle. Therefore, the measure of the acute angle is between 0° and 90°.

Figure 8. Student's work on activity 3

In figure 8, students can follow the instructions from the activity sheet to find out the definition of acute angle and the measure by combining two angles (right angles and angles with less than 90 degrees measure) found previously. From this activity, students can conclude that the measure of the acute angle is smaller than the right angle, which means the measure of an acute angle is between 0 and 90 degrees and can define an acute angle. Students can categorize angles into acute angles if the measure of the angle is given. In the discussion session, the teacher gives questions to students regarding the categorization of acute angles. Students can answer well such as students can categorize angles that have

the angle measure of 0.1 degrees and 91 degrees whether it is an acute angle or not.

In the construction of two angles to understand the measure of an acute angle, it can also be used to understand one of the relationships between angles, namely complementary angles. With guidance by the teacher, students can understand two concepts at the same time, this is following one of the characteristics of IRME (Widyawati et al., 2016), namely intertwining. IRME allows students to understand more than one concept at the same time and learning will be more meaningful if it is related to other learning topics.

In constructing an understanding of complementary angles, students measure first each of the two angles that form a right angle, then concluded that if students add up the two angles will add up to 90 degrees. Next, the teacher gives questions (notes during research) related to complementary angles to check students' understanding, and students can give a good solution by adding up the angles that form right angles and their sum is 90 degrees. This corresponds to the figure below.

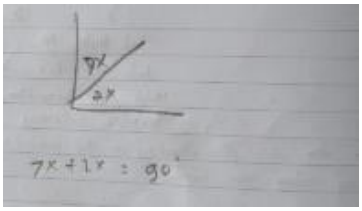
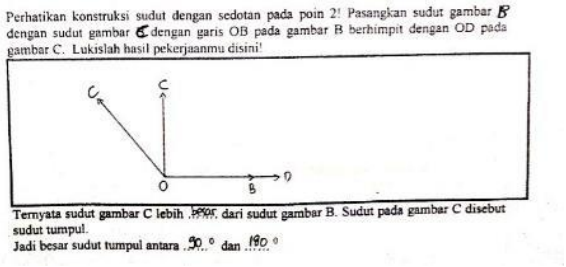


Figure 9. Teacher's Note on activity 3

With almost the same steps, students are asked to follow the instructions from the activity sheet to understand and define obtuse angles and the angle measure by combining two previously constructed angles, an angle with the measure of 90 degrees and an angle with the measure of more than 90 degrees.



Translation:

Pay attention to the angles construction that you have made. Match the angle of picture B with the angle of picture C with the arm OB on the angle of picture B coincide with the arm OD on picture D. Paint your work!

FIGURE

It shows that the angle of picture C is bigger than the angle of picture B. Angle C is called an obtuse angle. Therefore, the measure of the obtuse angle is between 90° and 180°.

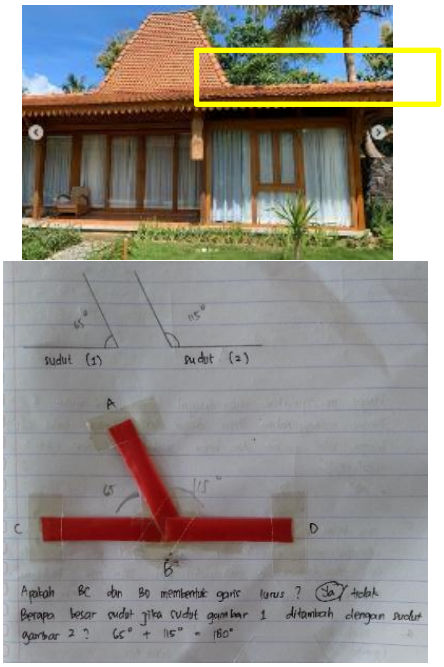
Figure 10. student's work on activity 3

Based on figure 10 and the results of the discussion, for understanding the definition of obtuse angles and how to know obtuse angle measure, students follow the steps of the activity sheet by combining the two angles found previously (right angle and angle that has a measure of more than 90 degrees). Furthermore, with the student's initial knowledge and with the given activity steps, students can define obtuse angles properly and can correctly state the measurement of obtuse angles, between 90 and 180 degrees. Then, students are also able to know the categorization of angles such as an angle of 181 degrees excluding obtuse angles. In addition, in the discussion session, the teacher also presented several acute angles, and students are asked to identify whether the given angles are obtuse angles or not. Students can also mention the right reasons according to what has been learned through previous activities.

In the categorization of the types of angles, students can identify other angles such as straight angles in the context.

From the results of the discussion, it can be concluded that students do not only find right angles, acute angles, and obtuse angles in the context. However, the students find another angle, namely a straight angle/straight line with 180 degrees measure. Students find straight lines in various parts of the joglo traditional house such as the roof, pillars, and floors.

Furthermore, the teacher provides stimulation to understand new concepts related to straight angles, namely supplementary angles. Students are asked to show and identify straight angles, especially on the roof of the joglo traditional house. Students are asked to explore further, such as a straight angle formed from two or more angles. Then, students are asked to construct the two angles that form a straight angle. The results of the construction can be seen in the following Figure:



Translation:

FIGURE
Do BC and BD form a straight line? Yes
What is the measure of the angle if the angle of picture 1 is added to the angle of picture 2? $65^0 + 115^0 = 180^0$

Figure 11. student's work on activity 3

Figure 11 shows that students can construct two angles that form a straight line on the roof of a joglo traditional house well. To understand supplementary angles, first, students find the measure of the angles of each angle and show whether the angles add up to 180 degrees (straight angles). In the learning process, the teacher always guides students. This activity also shows one of the characteristics of IRME, namely intertwining, where students can understand more than concepts at once.

Activity 4: solving the problem related to angles

Based on the activities given before, students can understand angles, can determine the measure of angles, and understand the types of angles such as right angles, acute angles, and obtuse angles, and also supplementary and complementary angles. Furthermore, students are given problems in daily life related to angles. Students use their knowledge from previous activities to solve given problems related to measuring, categorizing angles, and angles relationships. From student's work, students can complete the fourth activity well. The following are the results of student's work on activity 4:

"Andi wants to visit the Joglo Traditional House in Taman Mini Indonesia Indah. He left the house at 10.00 and arrived at his destination at 16.00. Andi is an architecture student who will make a miniature of Joglo Traditional House at TMII as his final project. Andi pays attention to

every detail of the Joglo Traditional House"

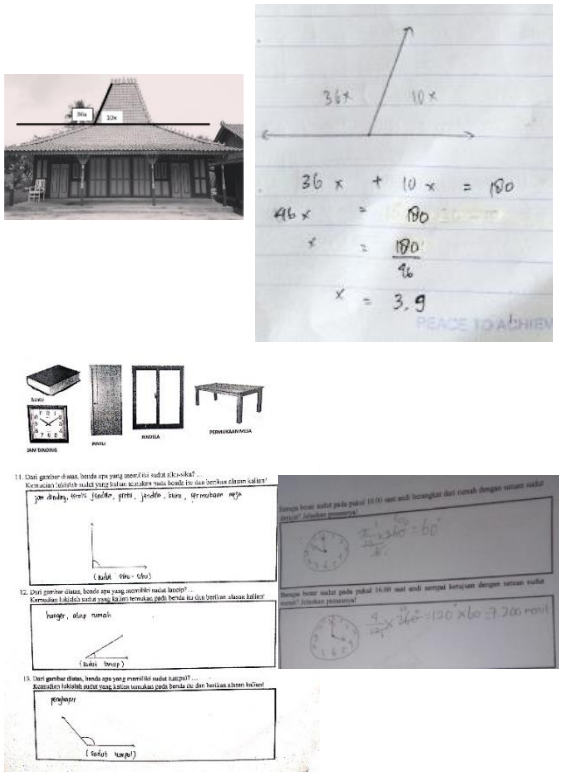
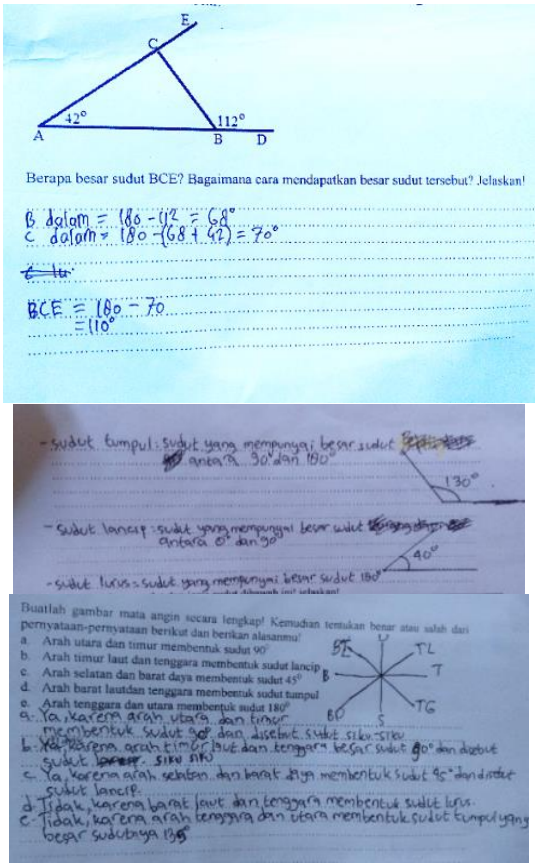


Figure 12. student's work on activity 4

From the results of student's work in Figure 12, it can be concluded that students can use knowledge from previous activities to work on a given problem such as being able to categorize objects in daily life based on the types of angles and students being able to determine the angle measure of the clock well. Besides that, students are also able to solve daily problems related to supplementary angles. In activity 4, there is a thing that needs to be emphasized by students, In categorizing angles, students only look at the shape of the angle first. Based on the results of the discussion, students only look at angles to categorize angles. With the guidance of the teacher, students understand that categorizing angles not only look at the shape of the angle but also checks the measure of the angle so that the categorization of angles can be done properly.

Post-test



Translation:

obtuse angle: an angle has measure between 90° and 180°
acute angle: an angle has measure between 0° and 90°

a) yes, because north-east forms an angle of 90° and is called a right angle
b) no, because the northeast and southeast have an angle of 90° and is called right angles
c) yes, because south-southwest forms an angle of 45° and forms an acute angle
d) no, because the northwest and south-east form a straight angle
e) no, because the north-southeast forms an impulse angle with an angle of 135°

Figure 13. student's work on post-test

Students have carried out the activities given. By applying the knowledge, they had from previous activities, students can do the post-test well, such as being able to determine the measure of

angles from the compass, mention the measure of obtuse and acute angles correctly and also able to solve the question using supplementary angles concepts. In addition, students show understanding of the material, therefore they can do the post-test much better than the pre-test.

Discussion

Based on the results of the study described above, actual learning is corresponding to the Hypothetical learning trajectory (HLT). The context of this study is the Joglo Traditional House that can be a bridge in knowing the relationship between mathematics and daily life that can help students understand angles well. This is following Prahmana (2012) which stated that mathematics learning in a context makes mathematics learning more meaningful and easier for students to understand.

The design of this study adapts to the Realistic Mathematics Education (RME) characteristics. According to Widyawati et al. (2016), there are five characteristics of RME, namely 1) the use of context. In this study, Joglo traditional house as a context in learning angles. This context is used as a starting point and as a source in learning angles material. 2) use of models. Models and symbols are used as a bridge for the students to understand the situational stage to a more abstract stage. The use of the model in this study began by observing the context video, then students are asked to identify and obtain information about angles and types of angles in the context. Furthermore, students can construct the information obtained in the context to develop informal knowledge into formal knowledge. 3) student contributions, in PMRI-based learning, students are the main role to be actively involved in solving problems and constructing their understanding which is assisted by activity sheets and teacher guidance to develop various informal strategies to solve problems. In this study, students are given the freedom and opportunity to express strategies and answers in the problem given 4) interactivity, the learning objectives will be achieved if in learning processes have good interaction and relationship between students and teachers, students and their friends, and students with learning instruments. There are several forms of interaction in this study such as discussion, explanation, agreement, questions, or reflections. 5) intertwinning, concepts of mathematics are closely related to structure. In angle material, so many structures and concepts are related to one another or previously studied material. That is called meaningful learning. Because in learning one material can relate to other material or knowledge that has been previously obtained. IRME allows students to understand more than one concept at the same time. In this study, students can learn more than one concept at once, such as understanding the concept of straight angles and supplementary angles at the same time.

CONCLUSION

Based on the results and the discussion that has been explained that this study produces a learning trajectory in the form of a series of activities and learning processes designed based on the Indonesian Realistic Mathematics Education which consists of 4 activities, namely observing the joglo traditional house video to understand the concept of angles, painting and measuring angles; categorize the types of angles; and solve contextual problems related to angles. Each learning process is adjusted to the characteristics of realistic mathematics education, namely use of

the context, use of the models, students' contributions, interactivity, and intertwining. This learning trajectory facilitates students to understand the material easily.

Based on the results and discussion of this study, it can be suggested that mathematics learning should not use unidirectional learning or teacher-centered which makes students passive, and their understanding of the material becomes less than optimal. There needs to be a mathematics learning design that can facilitate students to be actively involved, motivate students, and help students understand the material well. One way of designing that can be done is by using a realistic mathematics education with contexts that are familiar to students.

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