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#10961 Summary

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Submission

Authors	Nur Lailatul Fitri, Rully Charitas Indra Prahmana
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Author comments

Dear Prof. Masduki
Editor in Chief of Journal of Research and Advances in Mathematics Education (JRAMathEdu)

We hope this submission finds you well.

We, as the research collaboration team, are writing the manuscript entitled The Innovative Learning of Circle using Indonesian Realistic Mathematics Education for consideration for publication in the Journal of Research and Advances in Mathematics Education (JRAMathEdu). This manuscript was written using the JRAMathEdu manuscript template mentioned on the website.

This paper provides a comprehensive study on developing a learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. Researchers used a Ferriss wheel context as a starting point to support students' understanding of the circle. This research used design research that consists of three stages: preliminary design, design experiments, and retrospective analysis. This research was conducted in the even semester of the year 2019/2020. This research took place in SMP IT Al Khairaat. The subjects of this research were 20 eighth-grade students who consist of 12 male students and eight female students. The data obtained by this study is a learning trajectory of the circle using the Ferris wheel context. The design consists of four activities assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. The result showed that the Ferris wheel context could support students' understanding of the circle concept.

This paper also describes our original work and is not under consideration by any other journal. All authors approved the manuscript and this submission. The two co-authors do not have any conflict of interest regarding this manuscript. This document was reported as the research results we conducted as one of the requirements of our responsibility as a researcher in our university. This year, we didn't get funding for our research publication because of the COVID-19 Pandemic disease case in our country, so I would like to waive all article processing charges if our paper is accepted. Lastly, we do hope that this article can be published in this journal so that we can contribute our research results to your journal.

Thank you for receiving our manuscript and considering it for review. We do really appreciate your time and look forward to seeing your response.

Best Wishes,
Assoc. Prof. Dr. Rully Charitas Indra Prahmana

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Title and Abstract

Title Designing learning trajectory of circle using the context of Ferris wheel

Abstract Ferris wheel is one amusement playground that resembles a giant spinning wheel. Many students are familiar with the Ferris wheel in the mini version of it at night market festivals. This is the potential for learning mathematics. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) where students learn with contexts which are close to students' life as starting points. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning about circles. The research method is design research that consists of three stages: preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the circle parts, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the concept of a circle.

Indexing

Academic discipline and sub-disciplines	Mathematics Education
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The innovative learning of circle using Indonesian realistic mathematics education

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ABSTRACT

Ferris wheel is one of the amusement rides that resembles a giant spinning wheel. Ferris wheel context is rarely used in the learning of circle, so researchers interested in designing a learning trajectory of the circle using the Ferris wheel context. This research aims to develop a learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. Researchers used a Ferriss wheel context as a starting point to support students' understanding of the circle. This research used design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. This research was conducted in the even semester of the year 2019/2020. This research took place in SMP IT Al Khairaat. The subjects of this research were 20 eighth-grade students who consist of 12 male students and eight female students. The data obtained by this study is a learning trajectory of the circle using the Ferris wheel context. The design consists of four activities, which are assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. The result showed that the Ferris wheel context could support students' understanding of the circle concept.

Introduction

Thinking skill is one of the students' successes in learning. It's helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, & Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). While, high order thinking skill consists of three most top cognitive domains of Bloom Taxonomy (analysis, evaluation, creation) (Tanujaya, Mumu, & Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & Tanik Onal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities. Understanding is constructing meaning based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have (Marcelo & Yot-Domínguez, 2019). Students will understand the concept when they can construct the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new knowledge with prior knowledge.

The student with strong conceptual knowledge is likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle. Rejeki and Putri (2018) said that students difficulty understanding the area of a circle. Students difficulty in determining the center point and also the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Several studies were conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can support students in understanding the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. Are in line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learning the concept of the circumference of the circle. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding the mathematical concept. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, & Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the guidance of the teacher (Cobb, Zhao, & Visnovska, 2008).

Ferris wheel is one of the amusement rides that resembles a giant spinning wheel. The wheels on the Ferris wheel are suitable for problem-solving activities about the circumference of the circle (Alberghi, Resta, & Gaudenzi, 2013). Therefore, researchers interested in designing the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-graders.

Research Methods

The research method used is design research. The function of design research is to develop an intervention (such as programs, strategies, and materials) in teaching and learning activities as a solution to solving educational problems (Bakker, 2018). Design research becomes an alternative solution to answer the research question. This method allows researchers to know about the students learning process. Also, it helps researchers know which activities have been designed can support students' understanding of the concept of a circle. This research took place in SMP IT Al Khairaat in even semester. The subject in this research was eight-grader consist of 12 male students and eight female students. There are three stages in design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006), as follows.

Preliminary design

In this stage, researchers prepare the learning activities through a literature review about the concept of the circles and the Indonesian Realistic Mathematics Education (IRME) approach. Also, researchers obtain information about students 'difficulties in learning circles and the activities that can support students' understanding of circles. This information is used to design the Hypothetical Learning Trajectory (HLT). It consists of three components, a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1

The Overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the Ferris wheel ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly ▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly
Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This stage divided into two-cycle, namely teaching experiment and pilot experiment. In the teaching experiment, researchers implementing the HLT in a small group consisting of six students. In this cycle, researchers take a role as a teacher, and the teacher observes the learning process. Furthermore, researchers revise and improve the HLT according to the advice of the teacher class. The revised HLT in the first cycle implemented in this second cycle. This pilot experiment conducted in the natural classroom setting. Researchers collect the data to answer the research questions. The data were collected through classroom observation by video recording and students' worksheets. Researchers record the group discussion to know students' thinking during the learning process.

Retrospective analysis

After conducting a teaching experiment, researchers conducted a retrospective analysis. In this stage, the role of the learning trajectory becomes a guide in analyzing the collected data. Data analysis in this study was carried out by comparing the result of observations during the learning process with HLT that had been designed in the first stage. It allows researchers to investigate and explain how students get the concept of the circle. Video recording is the primary data needed to answer research questions. The video shows students learning activities and group discussions.

Results and Discussion

This research yields a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consist of four movements, which are assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher starts the lesson by asking students about the amusement ride. The teacher asks to know students' knowledge about the Ferris wheel context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurungan manuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though both of them are the same thing. So, the teacher introduces the Ferris wheel context that will be used as a starting point in the learning process (Yono, Zulkardi, & Nurjannah, 2019). The teacher shows a video about the Ferris wheel in Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel (Alberghi et al., 2013; Stevens & Moore, 2016), as seen in dialogue 2.

Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edupark.*
Students	:	*It is kurungan manuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurungan manuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurungan manuk* (Javanese language) than the Ferris wheel. After watching the video, students know that the Ferris wheel is another name for the *kurungan manuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context. Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel according to the instructions given on the worksheet (Júnior, Alves, & de Moura, 2013). First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels (Stevens & Moore, 2016). The use of the Ferris wheel in the learning process is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. It told that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Moreover, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location (Alberghi et al., 2013; Júnior et al., 2013). First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect

Meanwhile, another group draws the circle using the equipment (Alberghi et al., 2013). Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity is another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing for sure whether the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. They use a ruler to ensure that the distance of the center point to the side of the circle is the same. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. They found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students are spinning the wheel so that the red cabin is at the top of the wheel. They draw an illustration of a cabin showing four-passenger positions, as shown in Figure 3. This illustration will be used in the next activities.

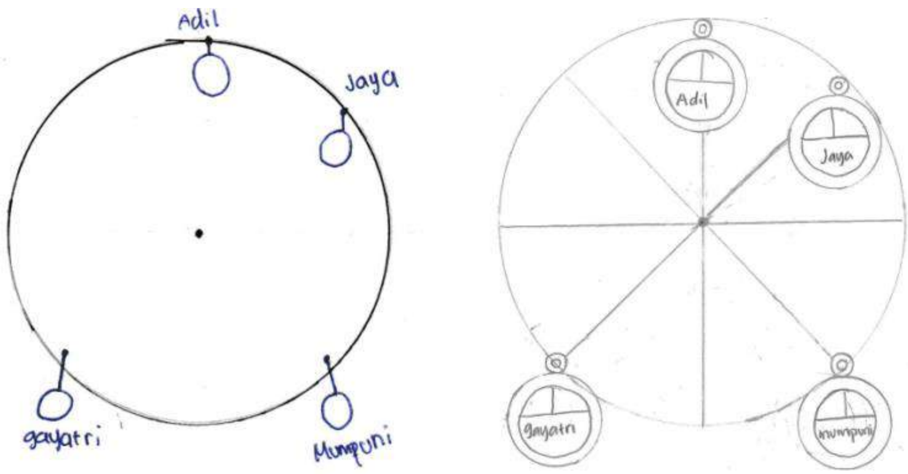

Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity is making a list of the parts of the circle. The students complete the table on the worksheet. In this activity, students discuss with their members of the group about the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion (Chianson, Kurumeh, & Obida, 2010).

Group 2 completes all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).

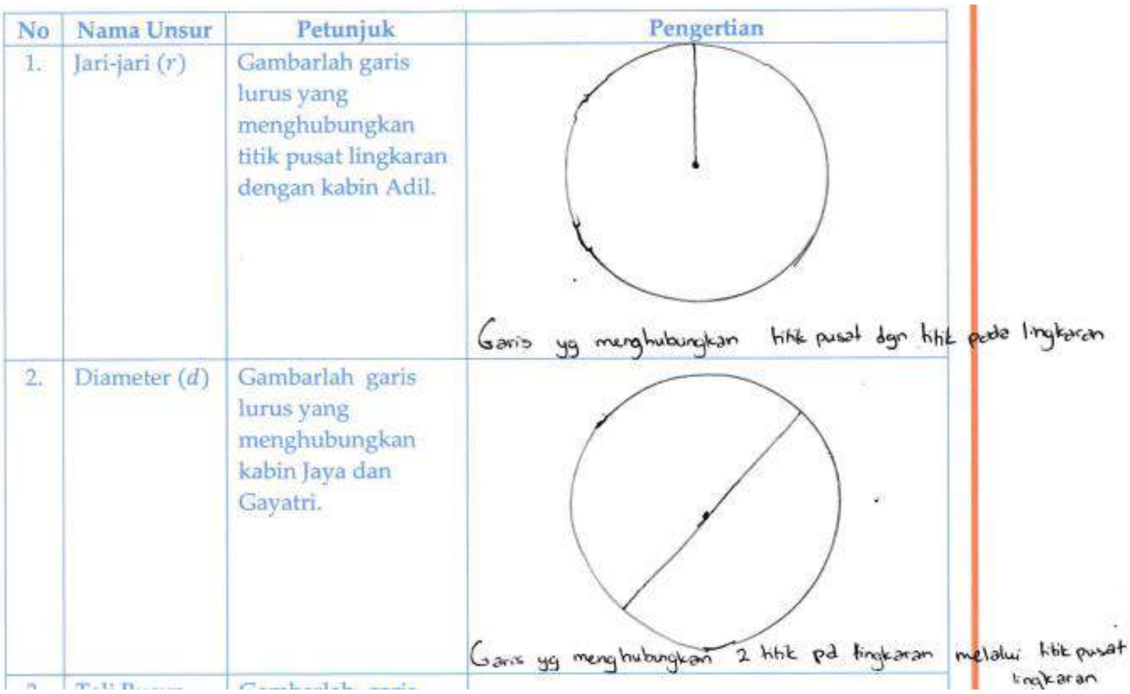

Figure 4. The part of the circle table by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.

Figure 5. Group 2 draw an illustration of an arc

The teacher's role is needed to guide students by giving clues (Bruce, 2007), as seen in dialogue 3.

Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they redraw a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Third, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.

No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari² dan 1 busur

Figure 6. Group 4 complete the part of the circle table

The teacher was giving clues to Group 4 (interactivity) so that they can define a sector (Bruce, 2007). They represent a sector as the area bounded by two radii and one circular arc, as seen in dialogue 4.

Dialogue 4.

Students	:	*Mrs, what is the sector?*
Teacher	:	*Which one a sector of a circle. Can you show it to me?*
Students	:	*This one, Mrs. The shaded area.*
Teacher	:	*Very good. So, it is bounded by ...*
Students	:	*Emm..this line and also this one*

Teacher : What is it called?
Students : Radius and arc.
Teacher : How many it has?
Students : There are two, Mrs.
Teacher : So, what is the sector?
Students : The sector is an area bounded by two and an arc.

Solving problems related to the parts of the circle

In this activity, students are asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the table in the previous activity, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplies the length of the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.

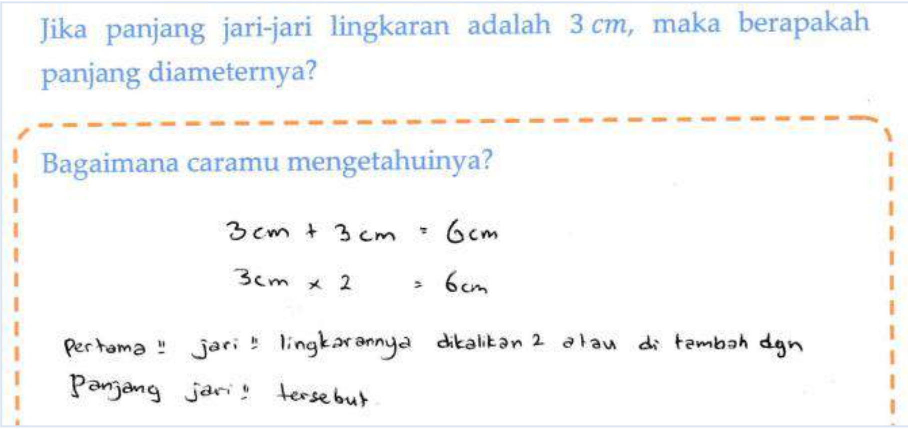

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

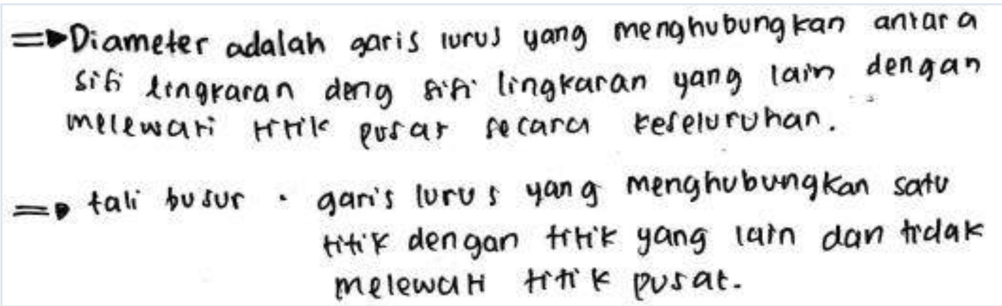

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as radius, diameter, arc, chord, sector, and segment.

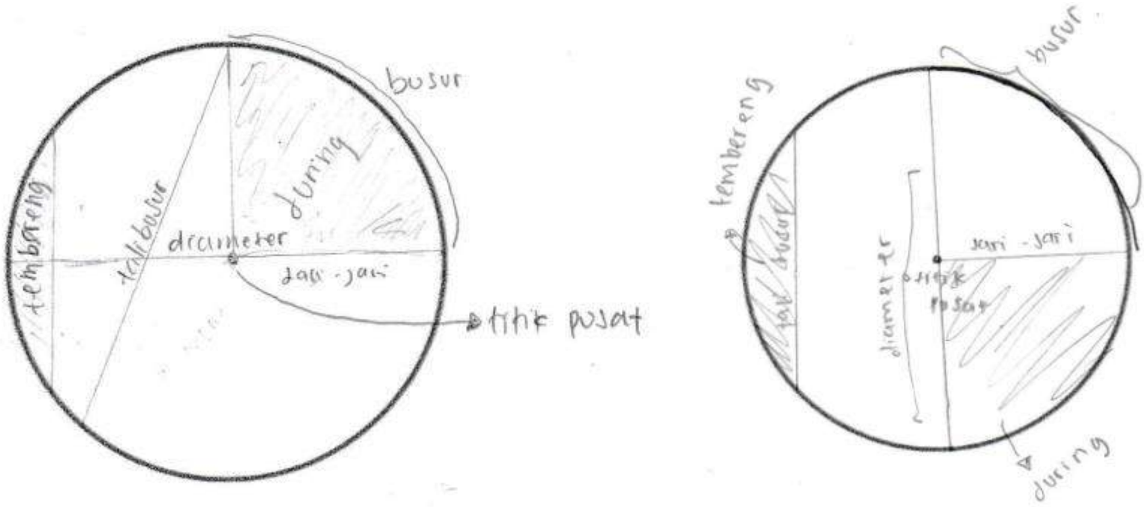

Figure 9. Students draw the part of the circle

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle. First, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel. It has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Second, students can draw an illustration of four passengers in the Ferris wheel.

Furthermore, they can determine the center point of a circle by using a folding strategy. Third, students are making a list of the parts of the circle. They can draw and define the elements of a circle, such as a radius diameter, chord, arc, sector, also segment. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

Acknowledgment

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Hasil initial review dari Editor diperoleh pada tanggal 30 Mei 2020 dan hasil revisi atas initial review di kirim kembali pada tanggal 3 Juni 2020 melalui system OJS JRAMathEdu.

JRAMathEdu (Journal of Research and Advances in Mathematics Education)

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Subject: [JRAMathEdu] Editor Decision (Preliminary Review) Delete

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I hope this email finds you well. Thank you for considering JRAMathEdu as your publication oulet.
We have reached a preliminary review of your submission to JRAMathEdu entitled , "The innovative learning of circle using Indonesian realistic mathematics education". Please find our suggestions to improve your manuscript in attachment. Please submit your revised manuscript through your account in our OJS.
We look forward to your revised manuscript.
Thank you.

Best regards,
Masduki
Editor-in-Chief

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Author
2020-06-03 07:11 AM

Subject: The innovative learning of circle using Indonesian realistic mathematics education Delete

Dear Prof. Masduki,

First of all, I would like to thank you for your valuable comments on our research paper. We have already revised our paper based on your suggestion.
Herewith, we attach the revised paper by using our account as an Author Version and hope that this paper will satisfy the standard of your journal paper, so that we can contribute with our research.

Regards,
Rully Charitas Indra Prahmana

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Hasil initial review dari editor dengan memberikan catatan pada artikel nya secara langsung.

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The innovative learning of circle using Indonesian realistic mathematics education

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ABSTRACT

Ferris wheel is one of the amusement rides that resembles a giant spinning wheel. Ferris wheel context is rarely used in the learning of circle, so researchers interested in designing a learning trajectory of the circle using the Ferris wheel context. This research aims to develop a learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. Researchers used a Ferriss wheel context as a starting point to support students' understanding of the circle. This research used design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. This research was conducted in the even semester of the year 2019/2020. This research took place in SMP IT Al Khairaat. The subjects of this research were 20 eighth-grade students who consist of 12 male students and eight female students. The data obtained by this study is a learning trajectory of the circle using the Ferris wheel context. The design consists of four activities, which are assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. The result showed that the Ferris wheel context could support students' understanding of the circle concept.

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2. The reason of the research is not strong enough if only based on the statement "Ferris wheel context is rarely used in the learning of circle"
3.The repetition of words like "this research" makes writing unattractive. please use pronoun
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5.How to collect the data? What are the instruments used?

Introduction

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Thinking skill is one of the students' successes in learning. It's helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, &Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman&Kuran, 2015; Kozikoğlu, 2018; Verdina&Gani, 2018). While, high order thinking skill consists of three most top cognitive domains of Bloom Taxonomy (analysis, evaluation, creation) (Tanujaya, Mumu, &Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, &TanikOnal, 2016; Apino&Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities. Understanding is constructing meaning based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, &Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have (Marcelo &Yot-Domínguez, 2019). Students will understand the concept when they can construct the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new knowledge with prior knowledge.

The student with strong conceptual knowledge is likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle. Rejeki and Putri (2018) said that students difficulty understanding the area of a circle. Students difficulty in determining the center point and also the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani& Julie, 2017; Rejeki& Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Several studies were conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can support students in understanding the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. Are in line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learning the concept of the circumference of the circle. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding the mathematical concept. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, &Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the guidance of the teacher (Cobb, Zhao, &Visnovska, 2008).

Ferris wheel is one of the amusement rides that resembles a giant spinning wheel. The wheels on the Ferris wheel are suitable for problem-solving activities about the circumference of the circle (Alberghi, Resta, &Gaudenzi, 2013). Therefore, researchers interested in designing the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-graders.

Research Methods

The research method used is design research. The function of design research is to develop an intervention (such as programs, strategies, and materials) in teaching and learning activities as a solution to solving educational problems (Bakker, 2018). Design research becomes an alternative solution to answer the research question. This method allows researchers to know about the students learning process. Also, it helps researchers know which activities have been designed can support students' understanding of the concept of a circle. This research took place in SMP IT Al Khairaat in even semester. The

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subject in this research was eight-grader consist of 12 male students and eight female students.There are three stages in design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer& Cobb, 2006), as follows.

Preliminary design

In this stage, researchers prepare the learning activities through a literature review about the concept of the circles and the Indonesian Realistic Mathematics Education (IRME) approach. Also, researchers obtain information about students 'difficulties in learning circles and the activities that can support students' understanding of circles. This information is used to design the Hypothetical Learning Trajectory (HLT). It consists of three components, a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, &Nieveen, 2006). The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The Overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the Ferris wheel ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly ▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly
Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This stage divided into two-cycle, namely teaching experiment and pilot experiment. In the teaching experiment, researchers implementing the HLT in a small group consisting of six students. In this cycle, researchers take a role as a teacher, and the teacher observes the learning process. Furthermore, researchers revise and improve the HLT according to the advice of the teacher class. The revised HLT in the first cycle implemented in this second cycle. This pilot experiment conducted in the natural classroom setting.

Researchers collect the data to answer the research questions. The data were collected through classroom observation by video recording and students' worksheets. Researchers record the group discussion to know students' thinking during the learning process.

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Retrospective analysis

After conducting a teaching experiment, researchers conducted a retrospective analysis. In this stage, the role of the learning trajectory becomes a guide in analyzing the collected data. Data analysis in this study was carried out by comparing the result of observations during the learning process with HLT that had been designed in the first stage. It allows researchers to investigate and explain how students get the concept of the circle. Video recording is the primary data needed to answer research questions. The video shows students learning activities and group discussions.

Results and Discussion

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This research yields a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consist of four movements, which are assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher starts the lesson by asking students about the amusement ride. The teacher asks to know students' knowledge about the Ferris wheel context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

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Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurunganmanuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though both of them are the same thing. So, the teacher introduces the Ferris wheel context that will be used as a starting point in the learning process (Yono, Zulkardi, &Nurjannah, 2019). The teacher shows a video about the Ferris wheel in Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel (Alberghi et al., 2013; Stevens & Moore, 2016), as seen in dialogue 2.

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Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edupark.*
Students	:	*It is kurunganmanuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurunganmanuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurunganmanuk* (Javanese language) than the Ferris wheel. After watching the video, students know that the Ferris wheel is another name for the *kurunganmanuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context. Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel according to the instructions given on the worksheet (Júnior, Alves, & de Moura, 2013). First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels (Stevens & Moore, 2016). The use of the Ferris wheel in the learning process is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel.

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Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. It told that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Moreover, they asked to draw the

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circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location (Alberghi et al., 2013; Júnior et al., 2013). First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect

Meanwhile, another group draws the circle using the equipment (Alberghi et al., 2013). Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity is another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing for sure whether the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. They use a ruler to ensure that the distance of the center point to the side of the circle is the same. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. They found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students are spinning the wheel so that the red cabin is at the top of the wheel. They draw an illustration of a cabin showing four-passenger positions, as shown in Figure 3. This illustration will be used in the next activities.

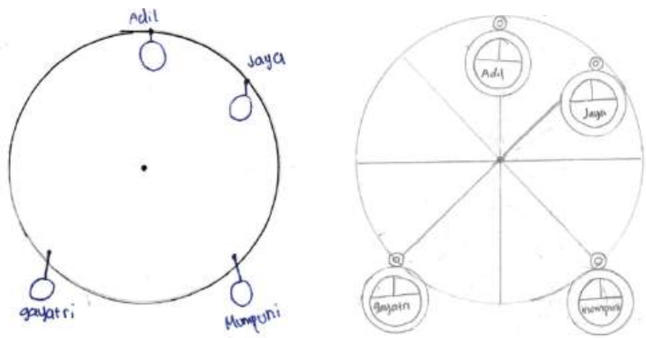

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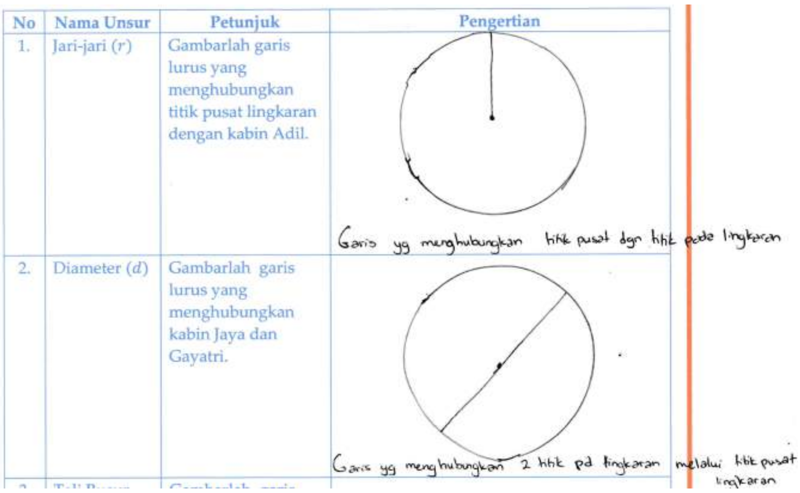
Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity is making a list of the parts of the circle. The students complete the table on the worksheet. In this activity, students discuss with their members of the group about the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion (Chianson, Kurumeh, &Obida, 2010).

Group 2 completes all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	Nama Unsur	Petunjuk	Pengertian
1.	Jari-jari (r)	Gambarlah garis lurus yang menghubungkan titik pusat lingkaran dengan kabin Adil.	Garis yg menghubungkan titik pusat dgn titik pada lingkaran
2.	Diameter (d)	Gambarlah garis lurus yang menghubungkan kabin Jaya dan Gayatri.	Garis yg menghubungkan 2 titik pd lingkaran melalui titik pusat lingkaran

Figure 4. The part of the circle table by group 2

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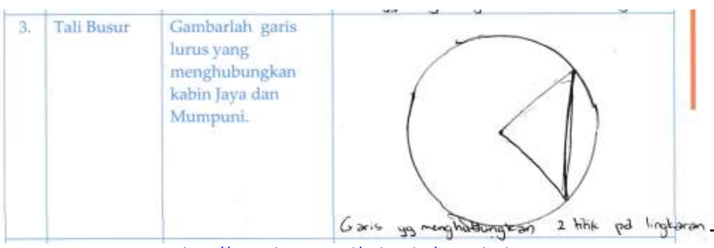
As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.



3.	Tali Busur	Gambarlah garis lurus yang menghubungkan kabin Jaya dan Mumpuni.	Garis yg menghubungkan 2 titik pd lingkaran

Figure 5. Group 2 draw an illustration of an arc

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The teacher's role is needed to guide students by giving clues (Bruce, 2007), as seen in dialogue 3.

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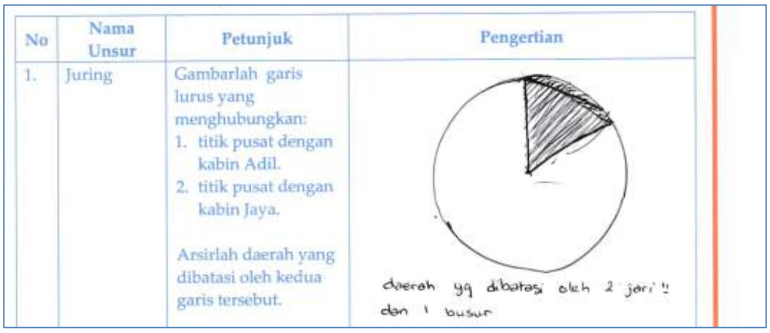
Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they redraw a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Third, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.



No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari'' dan 1 busur

Figure 6. Group 4 complete the part of the circle table

Commented [E24]: Please translate

The teacher was giving clues to Group 4 (interactivity) so that they can define a sector (Bruce, 2007). They represent a sector as the area bounded by two radii and one circular arc, as seen in dialogue 4.

Commented [E25]: See E8

Dialogue 4.

Students : *Mrs, what is the sector?*

Teacher : Which one a sector of a circle. Can you show it to me?
Students : This one, Mrs. The shaded area.
Teacher : Very good. So, it is bounded by ...
Students : Emm..this line and also this one
Teacher : What is it called?
Students : Radius and arc.
Teacher : How many it has?
Students : There are two, Mrs.
Teacher : So, what is the sector?
Students : The sector is an area bounded by two and an arc.

Solving problems related to the parts of the circle

In this activity, students are asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the table in the previous activity, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplies the length of the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.

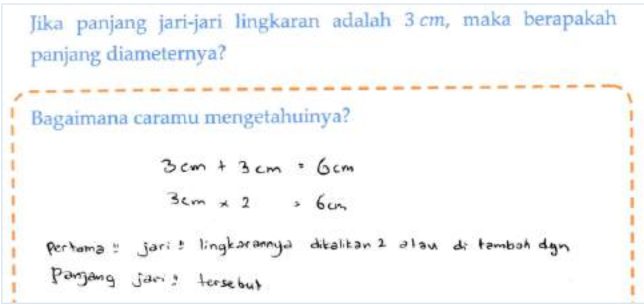


Figure 7. Group 2 explain their answer

Commented [E26]: Please translate

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

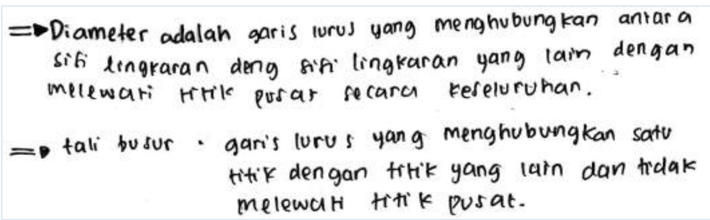


Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as radius, diameter, arc, chord, sector, and segment.

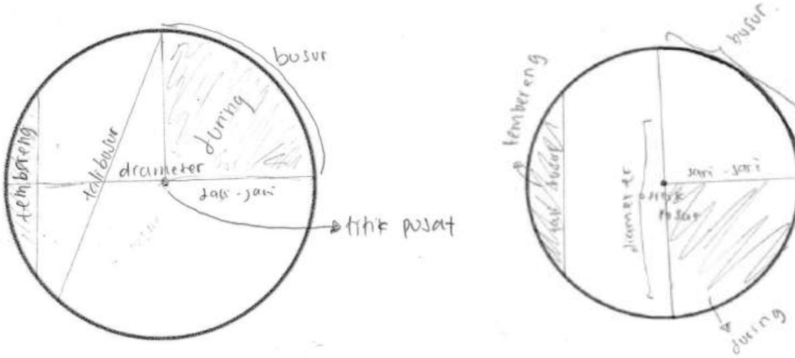


Figure 9. Students draw the part of the circle

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle. First, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel. It has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Second, students can draw an illustration of four passengers in the Ferris wheel.

Furthermore, they can determine the center point of a circle by using a folding strategy. Third, students are making a list of the parts of the circle. They can draw and define the elements of a circle, such as a radius diameter, chord, arc, sector, also segment. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. This wheel is a playground that closes to the student's daily activities. On the other hand, this playground has mathematical elements used in the circle's learning. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) that uses something that closes to students used as a starting point, namely context in its learning activities. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning circle. The research method used is design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the circle concept.

Introduction

Thinking skill is one of the students' successes in learning. It's helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, & Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). While, high order thinking skill consists of three most top cognitive domains of Bloom

Taxonomy (analysis, evaluation, and creation) (Tanujaya, Mumu, & Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & TanikOnal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities. It's constructing meaning based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have (Marcelo & Yot-Domínguez, 2019). Students will understand the concept when constructing the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new knowledge with prior knowledge.

Several studies were conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learn the concept of the circle's circumference. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding the mathematical concept. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, & Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, & Visnovska, 2008).

The student with strong conceptual knowledge is likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle (Rejeki & Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research would be to add alternative frameworks as a starting point in learning circles using daily activities that close to students.

Research Methods

The research method used is the design research. The function of this method is to develop an intervention (such as programs, strategies, and materials) in teaching and learning activities as a solution to solving educational problems (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, it helps to know which activities have been designed can support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The subject was eight-grade students consist of 12 male students and eight female students. There are three stages in design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary design

The preliminary design phase aims to formulate the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer & Cobb, 2006). There are three activities in this phase. Firstly, is choosing a teacher who teaches in the learning process. Secondly, is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly, obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information used to design the Hypothetical Learning Trajectory (HLT), which consists of three components, namely a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the Ferris wheel ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly

		▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly
Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase divided into two-cycle, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group consisting of six students. The phase purpose is to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle implemented in this second cycle. The second circle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Retrospective analysis

After conducting a teaching experiment, all the collected data analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory becomes a guide in analyzing the collected data. It allows to investigate and explain how students get the concept of the circle. Video recording is the primary data needed to answer research questions. The video shows students learning activities and group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principles explaining how and why this design works. Therefore, the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

Results and Discussion

This research develops a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consist of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher starts the lesson by asking students about the amusement park. The teacher asks to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurungan manuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though, both of them, *kurungan manuk* and Ferris wheel, are the same thing. The teacher introduces the Ferris wheel context that will be used as a starting point in the learning process. The existence of the tasks and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, & Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel. The same understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in dialogue 2.

Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edu park.*
Students	:	*It is kurungan manuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurungan manuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurungan manuk* (Javanese language) than the Ferris wheel. After watching the video, students know that the Ferris wheel is another name for the *kurungan manuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

The use of the Ferris wheel in the learning process is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. It told that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Moreover, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with Alberghi et al. (2013) research results. Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity is another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, They found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students are spinning the wheel so that the red cabin is at the top of the wheel. They draw an illustration of a cabin showing four-passenger positions, as shown in Figure 3. This illustration will be used in the next activities.

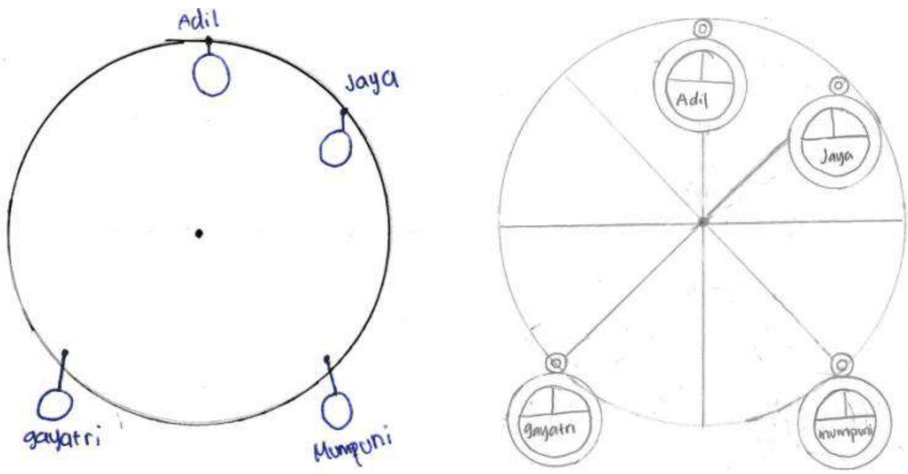
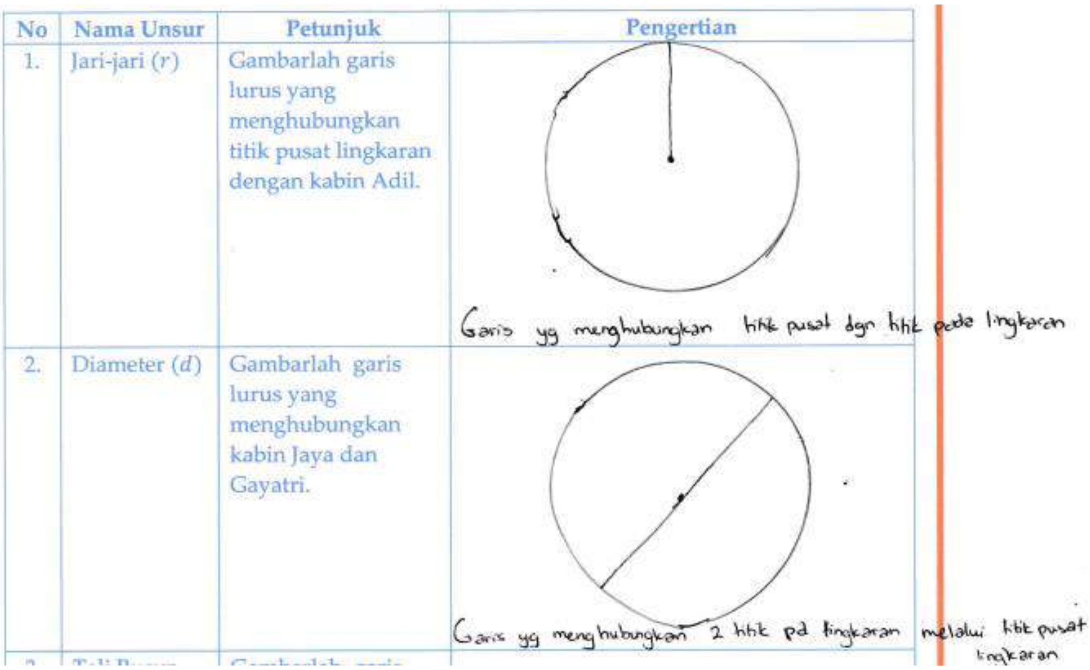


Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity is making a list of the parts of the circle. The students complete the table on the worksheet. In this activity, students discuss with their members of the group about the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion (Chianson, Kurumeh, & Obida, 2010).

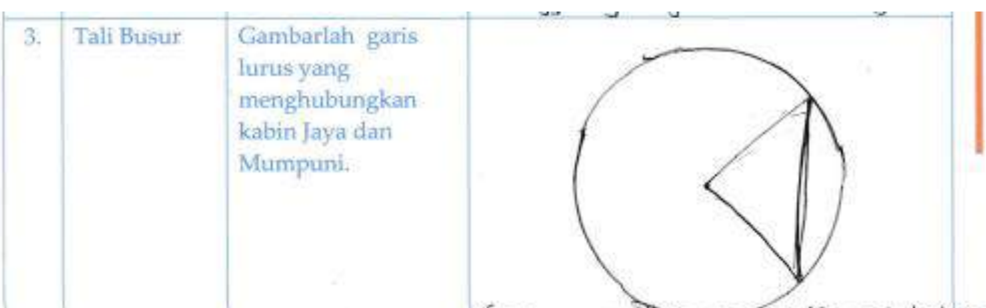
Group 2 completes all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle
2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.



3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of a chord of a circle

The teacher's role is needed to guide students by giving clues. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in dialogue 3.

Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they redraw a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.

No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari" dan 1 busur

1	Sector of a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" The area bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

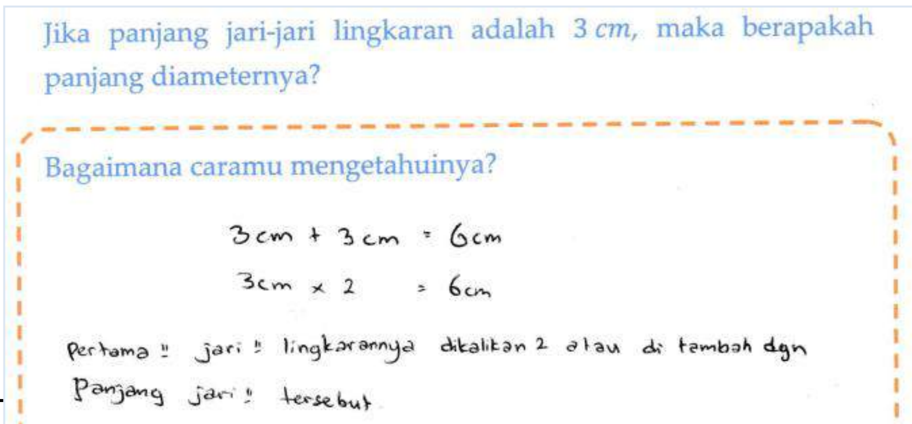
The teacher was giving clues to Group 4 (interactivity) so that they can define a sector. This activity provides a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in dialogue 4.

Dialogue 4.

Students	:	*Mrs, what is the sector?*
Teacher	:	*Which one a sector of a circle. Can you show it to me?*
Students	:	*This one, Mrs. The shaded area.*
Teacher	:	*Very good. So, it is bounded by ...*
Students	:	*Emm... this line and also this one*
Teacher	:	*What is it called?*
Students	:	*Radius and arc.*
Teacher	:	*How many it has?*
Students	:	*There are two, Mrs.*
Teacher	:	*So, what is the sector?*
Students	:	*The sector is an area bounded by two radius and an arc.*

Solving problems related to the parts of the circle

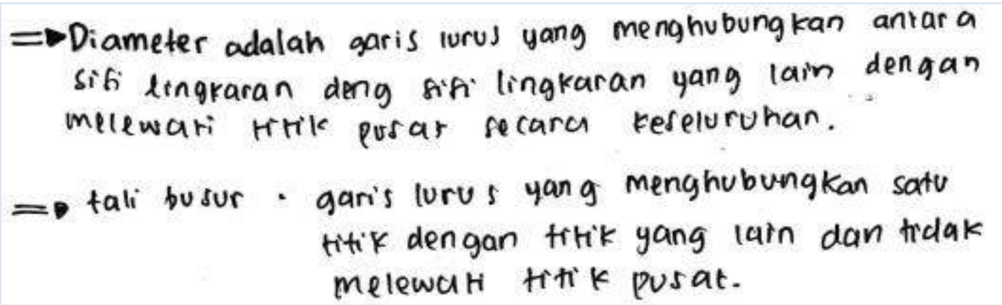
In this activity, students are asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplies the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.



If the length of the radius of the circle is 3 cm, what is the length of the diameter? How do you know? 3 cm + 3 cm = 6 cm 3 cm x 2 = 6 cm Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

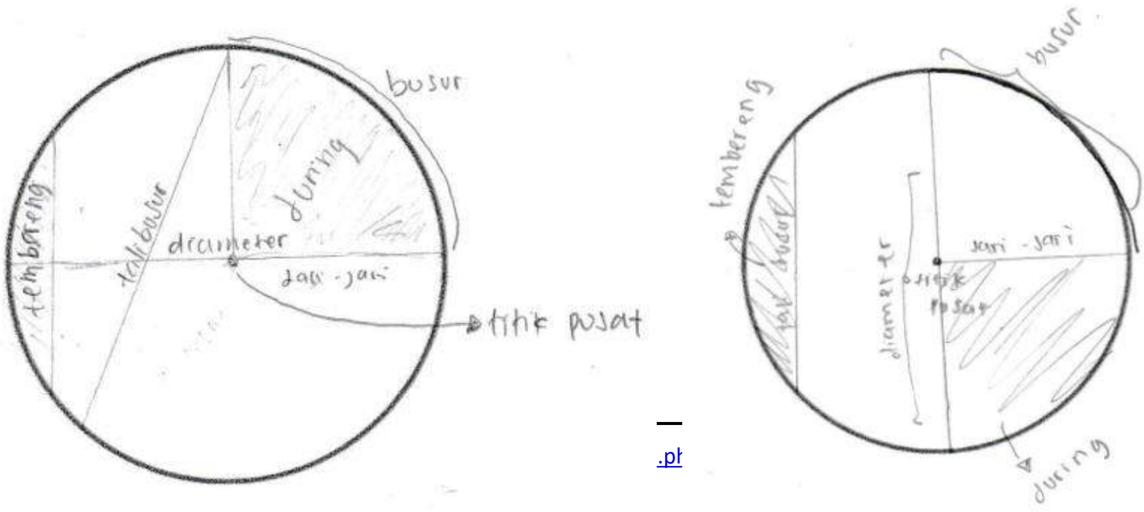

=> Diameter adalah garis lurus yang menghubungkan antara sisi lingkaran deng sisi lingkaran yang lain dengan melewati titik pusat secara keseluruhan.

=> tali busur · garis lurus yang menghubungkan satu titik dengan titik yang lain dan tidak melewati titik pusat.

The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Tembereng = segment *Tali busur* = chord *Diameter* = diameter *Juring* = sector	*Jari-jari* = radius *Titik pusat* = center point *Busur* = arc

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be given by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students understand the concept of the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani & Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah & Prahmana, 2017; Rejeki & Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle. First, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel. It has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Second, students can draw an illustration of four passengers in the Ferris wheel.

Furthermore, they can determine the center point of a circle by using a folding strategy. Third, students are making a list of the parts of the circle. They can draw and define the elements of a circle, such as a radius diameter, chord, arc, sector, also segment. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

The results of this study can be used to implement a learning trajectory that has been designed more broadly. It also can be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of the concept of circles.

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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. This wheel is a playground that closes to the student's daily activities. On the other hand, this playground has mathematical elements used in the circle's learning. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) that uses something that closes to students used as a starting point, namely context in its learning activities. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning circle. The research method used is design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the circle concept.

Commented [M1]: Please explain what is the results?

Introduction

Thinking skill is one of the students' successes in learning. It's helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, &Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman&Kuran, 2015; Kozikoğlu, 2018; Verdina&Gani, 2018). While, high order thinking skill consists of three most top cognitive domains of Bloom

Commented [M2]: What is the students' problem so you need to do this research?

Commented [M3]: You need to explore the previous research about circle, what they did in their research, and what is the results, so it will be help you to construct the learning trajectory.

Commented [M4]: What is the relation thinking skill with your research?

Taxonomy (analysis, evaluation, and creation) (Tanujaya, Mumu, &Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, &TanikOnal, 2016; Apino&Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities. It's constructing meaning based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, &Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have (Marcelo &Yot-Domínguez, 2019). Students will understand the concept when constructing the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new knowledge with prior knowledge.

Several studies were conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learn the concept of the circle's circumference. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding the mathematical concept. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, &Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, &Visnovska, 2008).

The student with strong conceptual knowledge is likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle (Rejeki& Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani& Julie, 2017; Rejeki& Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research would be to add alternative frameworks as a starting point in learning circles using daily activities that close to students.

Research Methods

The research method used is the design research. The function of this method is to develop an intervention (such as programs, strategies, and materials) in teaching and learning activities as a solution to solving educational problems (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, it helps to know which activities have been designed can support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The subject was eight-grade students consist of 12 male students and eight female students. There are three stages in design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer& Cobb, 2006).

Commented [M5]: Please explain why do you used the design research in this research?
Please explain what is your method to collect the data, what is the research instrument, how do you analyze the data?

Preliminary design

The preliminary design phase aims to formulate the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer& Cobb, 2006). There are three activities in this phase. Firstly, is choosing a teacher who teaches in the learning process. Secondly, is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly, obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information used to design the Hypothetical Learning Trajectory (HLT), which consists of three components, namely a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, &Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Commented [M6]: It will be better if you describe what is the real activity that a teacher and students will do in the real classroom.

Commented [M7]: What you mean with this activity?

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the Ferris wheel ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly

		▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly
Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase divided into two-cycle, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group consisting of six students. The phase purpose is to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle implemented in this second cycle. The second circle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Commented [M8]: How do you choose this students? Will they follow the second phase?

Retrospective analysis

After conducting a teaching experiment, all the collected data analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory becomes a guide in analyzing the collected data.It allows to investigate and explain how students get the concept of the circle. Video recording is the primary data needed to answer research questions. The video shows students learning activities and group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principlesexplaining how and why this design works. Therefore, the role ofHLT has been designed compared to the learning process carried out by students so that aninvestigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

Results and Discussion

Commented [M9]: Please focus to analyze the effect of your intervention. An example, the students made a Ferris Whale. Please explain the impact of a Ferris Whale that you use on the formation of students' thinking processes and what is the teacher's support that will help the students to construct the concept.
I think the main goal of your learning trajectory are the students can understand about the concept of the part of circle. So, please explain more detail, the effect of your activity to your main goal.

This research develops a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consist of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher starts the lesson by asking students about the amusement park. The teacher asks to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurunganmanuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though, both of them, *kurunganmanuk* and Ferris wheel, are the same thing. The teacher introduces the Ferris wheel context that will be used as a starting point in the learning process. The existence of the tasks and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, &Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel. The same understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in dialogue 2.

Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edupark.*
Students	:	*It is kurunganmanuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurunganmanuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurunganmanuk* (Javanese language) than the Ferris wheel. After watching the video, students know that the Ferris wheel is another name for the *kurunganmanuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

The use of the Ferris wheel in the learning process is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. It told that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Moreover, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways

Commented [M10]: How are their position in the Ferris Whale? Explain your hypothesis first about how students might do to determine the location of the center of the circle from the fourth position of the person. After that, just explain, what is done by students in the real class.

of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with Alberghi et al. (2013) research results. Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity is another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, They found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students are spinning the wheel so that the red cabin is at the top of the wheel. They draw an illustration of a cabin showing four-passenger positions, as shown in Figure 3. This illustration will be used in the next activities.

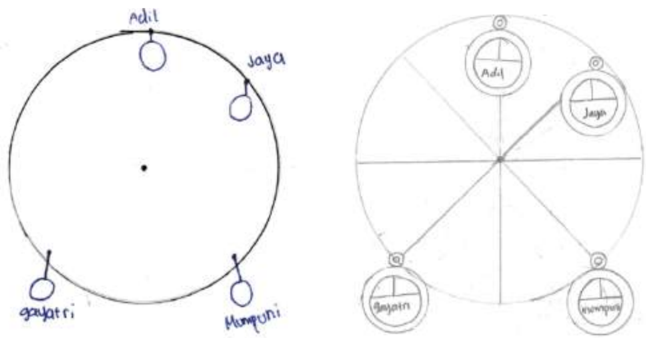
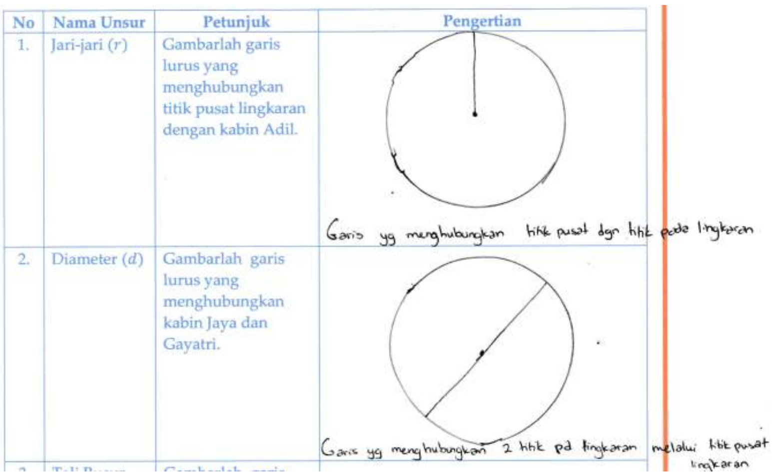


Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity is making a list of the parts of the circle. The students complete the table on the worksheet. In this activity, students discuss with their members of the group about the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion (Chianson, Kurumeh, &Obida, 2010).

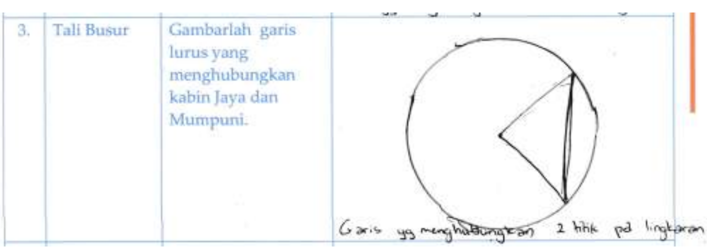
Group 2 completes all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle
2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.



3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of achord of a circle

The teacher's role is needed to guide students by giving clues. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in dialogue 3.

Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they redraw a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.

1	Sectorof a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" Thearea bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

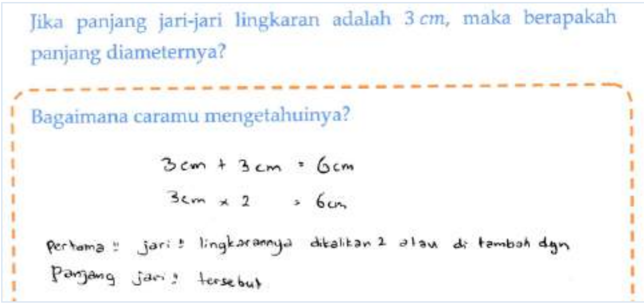
The teacher was giving clues to Group 4 (interactivity) so that they can define a sector. This activity provides a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in dialogue 4.

Dialogue 4.

Students	:	*Mrs, what is the sector?*
Teacher	:	*Which one a sector of a circle. Can you show it to me?*
Students	:	*This one, Mrs. The shaded area.*
Teacher	:	*Very good. So, it is bounded by ...*
Students	:	*Emm… this line and also this one*
Teacher	:	*What is it called?*
Students	:	*Radius and arc.*
Teacher	:	*How many it has?*
Students	:	*There are two, Mrs.*
Teacher	:	*So, what is the sector?*
Students	:	*The sector is an area bounded by two radius and an arc.*

Solving problems related to the parts of the circle

In this activity, students are asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplies the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is $2 \times 3 = 6$ cm.



If the length of the radius of the circle is 3 cm, what is the length of the diameter?

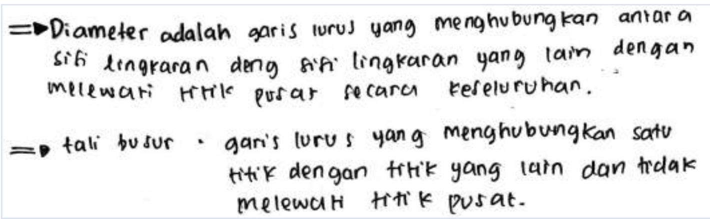
How do you know?

3 cm + 3 cm = 6 cm
3 cm x 2 = 6 cm

Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

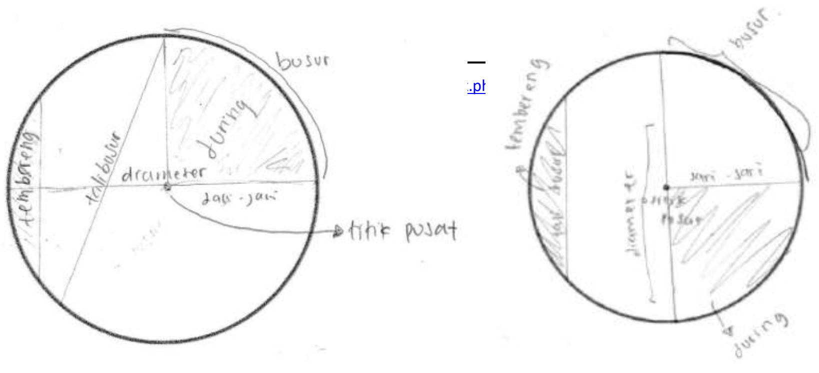


The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole

a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Tembereng = segment *Talibusur* = chord *Diameter* = diameter *Juring* = sector	*Jari-jari* = radius *Titikpusat* = center point *Busur* = arc

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be given by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students understand the concept of the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani& Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah&Prahmana, 2017; Rejeki& Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle. First, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a miniature of a Ferris wheel. It has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Second, students can draw an illustration of four passengers in the Ferris wheel.

Furthermore, they can determine the center point of a circle by using a folding strategy. Third, students are making a list of the parts of the circle. They can draw and define the elements of a circle, such as a radius diameter, chord, arc, sector, also segment. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

The results of this study can be used to implement a learning trajectory that has been designed more broadly. It also can be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of the concept of circles.

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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. This wheel is a playground that closes to the student's daily activities. On the other hand, this playground has mathematical elements used in the circle's learning. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) that uses something that closes to students used as a starting point, namely context in its learning activities. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning circle. The research method used is design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the parts of the circle, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the circle concept.

Introduction

Thinking skill is one of the students' successes in learning. It is helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, &Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). Higher order thinking skill consists of three most top cognitive domains of Bloom Taxonomy

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(analysis, evaluation, and creation) (Tanujaya, Mumu, &Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & TanikOnal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities. It's constructing meaning based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, &Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have (Marcelo &Yot-Domínguez, 2019). Students will understand the concept when constructing the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new knowledge with prior knowledge.

Several studies have been conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learn the concept of the circle's circumference. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding mathematical concepts. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, &Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, &Visnovska, 2008).

The students with strong conceptual knowledge are likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle (Rejeki& Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research provides an alternative framework for learning circles using daily activities that close to students.

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Research Methods

The research method used in this study is design research. In design research, an intervention (such as programs, strategies, and materials) for teaching and learning is designed to solve a problem to address in education (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, it helps to know which activities have been designed can support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The participants were eight-grade students which consisted of 12 male students and eight female students. There were three stages in this design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary design

The preliminary design phase formulated the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer & Cobb, 2006). There were three activities in this phase. Firstly, is choosing a teacher who teaches in the learning process. Secondly, is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly, obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information used to design the Hypothetical Learning Trajectory (HLT), which consists of three components, namely a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the Ferris wheel ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly

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		▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly
Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase was divided into two cycles, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group consisting of six students. The purpose of this phase was to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle implemented in this second cycle. The second cycle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Retrospective analysis

After conducting a teaching experiment, all the collected data analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory became a guide in analyzing the collected data. It allowed to investigate and explain how students understood the concept of the circle. Video recording was the primary data needed to answer research questions. The video showed students learning activities and group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principles explaining how and why the design will work. Therefore, the role of HLT has been designed compared to the learning process carried out by students so that aninvestigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

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Results and Discussion

This research developed a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consisted of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher started the lesson by asking students about the amusement park. The teacher asked questions to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

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Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurunganmanuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though, both of them, *kurunganmanuk* and Ferris wheel, are the same thing. The teacher introduces the Ferris wheel context that would be used as a starting point in the learning process. The existence of the tasks and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, &Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel. The same understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in dialogue 2.

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Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edupark.*
Students	:	*It is kurunganmanuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurunganmanuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurunganmanuk* (Javanese language) compared to the term "Ferris wheel". After watching the video, students know that the Ferris wheel is another name for the *kurunganmanuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

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Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

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The use of the Ferris wheel in the learning process is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel.

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Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. It told that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin.

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Students are asked to determine the center of the circle. Moreover, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with Alberghi et al. (2013) research results. Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

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Meanwhile, other groups draw circles using the equipment. This strategy is in line with the results of the study of Alberghi et al. (2013), which states that most students will not be able to draw a circle without using several supporting equipment.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity demonstrated another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, They found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

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Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students spinned the wheel so that the red cabin was at the top of the wheel. They drew an illustration of a cabin showing the positions of four passengers, as shown in Figure 3. This illustration will be used in the next activities.

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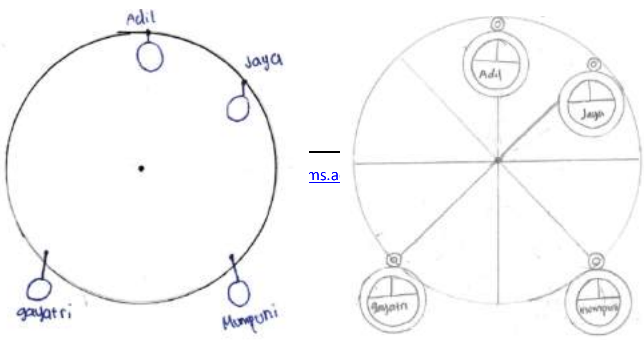

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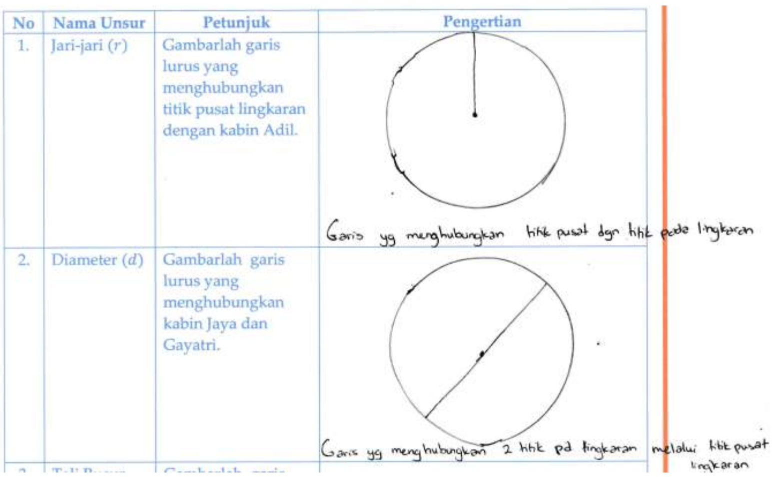
Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity involved students making a list of the parts of the circle. The students completed the table on the worksheet. In this activity, students discussed with their members of their group the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion (Chianson, Kurumeh, &Obida, 2010).

Group 2 completed all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	Nama Unsur	Petunjuk	Pengertian
1.	Jari-jari (r)	Gambarlah garis lurus yang menghubungkan titik pusat lingkaran dengan kabin Adil.	Garis yg menghubungkan titik pusat dgn titik pada lingkaran
2.	Diameter (d)	Gambarlah garis lurus yang menghubungkan kabin Jaya dan Gayatri.	Garis yg menghubungkan 2 titik pd lingkaran melalui titik pusat lingkaran

No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle

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2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.

3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of achord of a circle

The teacher's role was to guide the students by giving clues. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in dialogue 3.

Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they re-drew a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that.

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No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari'!! dan 1 busur

1	Sectorof a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" Thearea bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

The teacher provided clues to Group 4 (interactivity) so that they could define a sector. This activity provided a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in dialogue 4.

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Dialogue 4.

Students	:	*Mrs XXX, what is the sector?*
Teacher	:	*Which one a sector of a circle. Can you show it to me?*
Students	:	*This one, Mrs. The shaded area.*
Teacher	:	*Very good. So, it is bounded by ...*
Students	:	*Emm... this line and also this one*
Teacher	:	*What is it called?*
Students	:	*Radius and arc.*
Teacher	:	*How many it has?*
Students	:	*There are two, Mrs.*
Teacher	:	*So, what is the sector?*
Students	:	*The sector is an area bounded by two radius and an arc.*

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Solving problems related to the parts of the circle

In this activity, students were asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplied the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.

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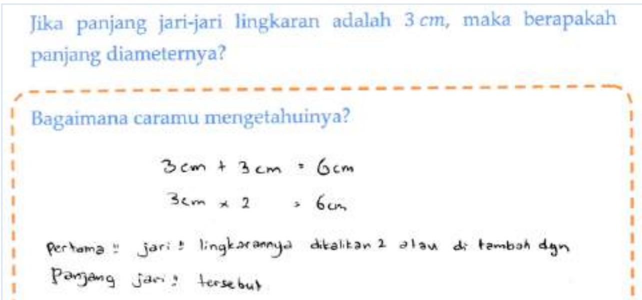
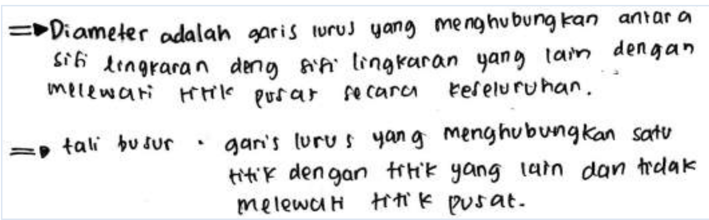


If the length of the radius of the circle is 3 cm, what is the length of the diameter? How do you know? 3 cm + 3 cm = 6 cm 3 cm x 2 = 6 cm Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

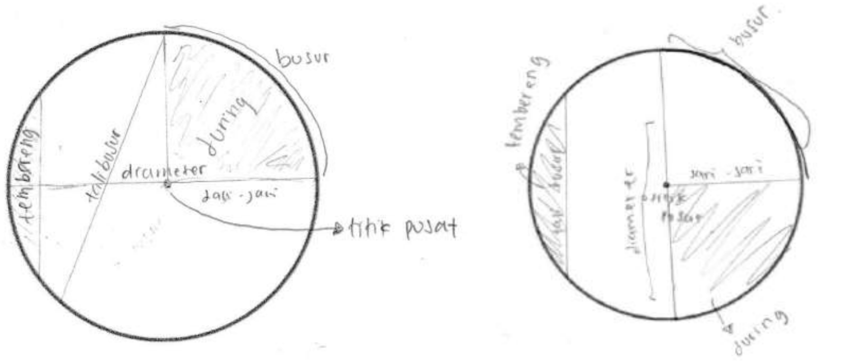


The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole

a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Tembereng = segment	*Jari-jari* = radius
Talibusur = chord	*Titikpusat* = center point
Diameter = diameter	*Busur* = arc
Juring = sector	

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be given by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students showed that, overall, the average score of the students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students had understood the concepts related to the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani& Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah&Prahmana, 2017; Rejeki& Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using

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the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle. First, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Then, students try to assemble a miniature of a Ferris wheel. It has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Second, students can draw an illustration of four passengers in the Ferris wheel.

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Furthermore, they can determine the center point of a circle by using a folding strategy. Third, students are making a list of the parts of the circle. They can draw and define the elements of a circle, such as a radius diameter, chord, arc, sector, also segment. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

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The results of this study can be used to implement a learning trajectory that has been designed more broadly. It also can be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of the concept of circles.

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Hasil revisi sesuai saran dari 2 reviewer dan sejumlah file pendukung di kirim pada tanggal 23 Juni 2020.

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Subject: Designing learning trajectory of circle using the context of Ferris wheel

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Dear Prof. Masduki
Editor in Chief of Journal of Research and Advances in Mathematics Education (JRAMathEdu)

Greetings from Yogyakarta and wishing you a great day with happiness and healthy condition in this era COVID-19.

First of all, I would like to thank you for your valuable comments from your reviewer on our research paper. We have already revised our paper based on the two reviewers' suggestions.

Herewith, we attach the revised paper and also Review's Comment & Response Form on JRAMathEdu with Paper ID 10961 by using our account as an Author Version and hope that this paper will satisfy the standard of your journal paper, so that we can contribute with our research. To ensure there are no more grammatical errors in our paper, we use Grammarly Premium as our assistant tool and discuss it with our colleagues who are studying abroad to make sure our article meets the standard of the scientific manuscript in English.

Thank you very much for your help and kindness. We do Really appreciate it.

Regards,
Rully Charitas Indra Prahmana

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“Designing learning trajectory of circle using the context of Ferris wheel”

[Paper ID: 10961]

Review's Comment & Response Form on JRAMathEdu
[10961]

Reviewer	Reviewer's Comment	Respond to Reviewer
1	You mean "Thinking skill is one important factor of students' success in learning"? Please phrase it properly	Thinking skill is one essential factor of students' success in learning mathematics.
	Understanding is one of the three basic level capabilities. It's constructing meaning based on prior knowledge.	Understanding is one of the three basic level capabilities which constructing the meaning or concept based on prior knowledge.
	Furthermore, understanding is learning by integrating new knowledge into the knowledge they already have.	Furthermore, understanding learned by integrating new insight into the knowledge they already have.
	Several studies have been conducted to overcome those problems by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach.	Several studies have been conducted to support students' understanding by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach.
	This discussion should still be generic. Shouldn't be talking about circles at this point.	In this part, we would like to emerge the correlation between student understanding and the concept or circle. So, we introduce a little bit in this part.
	Mention that you are discussing about specific example from this paragraph onwards. Otherwise the flow of the paragraphs is not coherent	We already revise this part
	Also mention that this framework can be used for studying other mathematics concept. Otherwise, a framework for only studying one topic is NOT efficient.	In design research, we would like to produce a local instructional theory. Local, in this term, means in the specific topic. For more detail, we can see in the research method part.
	It becomes an alternative solution to answer the research question and know about the students learning process. Also, it helps to know which activities have been designed can support students' understanding of the concept of a circle.	It becomes an alternative solution to answer the research question and know about the students learning process. Also, the design research method helps to determine which activities have been designed to support students' understanding of the concept of a circle.
	You need to elaborate more since the title of your paper is on learning trajectory.	We think four sentences are enough to explain the learning trajectory. For more detail, the reader can read Van den

		Akker, Gravemeijer, McKenney, and Nieveen's (2006) research whose tell more about it.
	Even though, both of them, *kurunganmanuk* and Ferris wheel, are the same thing.	Even though both of them, kurungan manuk and Ferris wheel, are the same thing.
	What is the difference between task and exercise?	We already revise this part
	What do you mean by this “same understanding”?	The student and teacher’s understanding about the context.
	Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively	Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively can help students’ understanding a mathematical concept.
	Something is wrong here: How can the use of Ferris Wheel be one of the characteristics of IRME approach? Characteristic means it occurs in ALL IRME tasks. Rather, you mean “real world context, such as the Ferris wheel”? Please paraphrase.	The use of something that related or closed to student, such as the Ferris wheel, in the learning process, is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel. It means that the Ferris wheel is a context in this learning activity.
	Need to elaborate a little bit here. I don’t know what you mean. How do these groups’ activity in line with Alberghi et al’s research result? There is no link here.	We already revise and explain more this part
	What do you mean? Do you mean (1) in this study, you found that the students retained concept and recall faster? Or (2) you conducted the activity this way because of the study you cited? Not clear from your context.	Students retained the mathematical concept and recall faster their knowledge by group discussion. This result is supported by Chianson, Kurumeh, and Obida (2010) who explains that cooperative learning that focuses on group discussion can influence students’ understanding of a mathematical concept faster.
	Does Figure 5 include both the figures and the table below it? If yes, please make it clear. Same for Figure 4.	The table directly below the Figure is the translation result information in Bahasa from the Figure into English.

	It is good to elaborate the guideline of the clues that teachers give to students. You can't possibly just ask the teachers to provide any clue without training them.	The teacher gives a clue in the form of student worksheets and questions during the discussion process that serves to guide students in finding a mathematical concept. It can be seen from the results of students' answers and the dialogue between teachers and students.
	I am worried about the validity of this conclusion. But I will let this pass. Good for the authors to justify further	We think the validity of our conclusion can be seen in the activity that we explained in the result and discussion part, and the students' result of the final assignment.
	Summarise in one short paragraph. No need to repeat the key mathematics here.	We already revise and explain more this part
	Several grammatical errors	We already revise it
2	Please explain what is the results?	The research results have been explained in the three last sentences.
	What is the students' problem so you need to do this research?	The students' problems have been explained in the two last paragraphs
	You need to explore the previous research about circle, what they did in their research, and what is the results, so it will be help you to construct the learning trajectory.	The previous research about circle have been explained in the third, fourth, and fifth paragraph.
	What is the relation thinking skill with your research?	The relationship between thinking skill and my research has been explained in the first and second paragraph.
	Please explain why do you used the design research in this research? Please explain what is your method to collect the data, what is the research instrument, how do you analyze the data?	The reason why I use Design Research has been explained in the first paragraph in Page 2. The method to collect the data, the research instrument, and the data analyze have been explained in the Retrospective analysis section in Page 4.
	It will be better if you describe what is the real activity that a teacher and students will do in the real classroom.	In design research, we use HLT consisting of activities, goals, and conjectures to guide a research in learning process. For the explanation of

		the real activities in the classroom have been explained in the design experiment of result and discussion section.
	What you mean with this activity?	I already explained more about this activity
	How do you choose this students? Will they follow the second phase?	I already explained more about the students. They are not following in the second phase.
	Please focus to analyze the effect of your intervention. An example, the students made a Ferris Whale. Please explain the impact of a Ferris Whale that you use on the formation of students' thinking processes and what is the teacher's support that will help the students to construct the concept.	The effect of the intervention has been explained in all activities of the results and discussion part. Usually, it ends with a concluding statement of the impact of the treatment after we analyze it by comparing it with the previous research.
	I think the main goal of your learning trajectory are the students can understand about the concept of the part of circle. So, please explain more detail, the effect of your activity to your main goal.	The result has been explained in the second paragraph on Page 12.
	How are their position in the Ferris Whale? Explain your hypothesis first about how students might do to determine the location of the center of the circle from the fourth position of the person. After that, just explain, what is done by students in the real class.	We have been explaining it in the third paragraph on Page 6 and illustrating it in Figure 3.

Other:

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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. This wheel is a playground that closes to the student's daily activities. On the other hand, this playground has mathematical elements used in the circle's learning. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) that uses something that closes to students used as a starting point, namely context in its learning activities. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning circle. The research method is design research that consists of three stages, namely preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the circle parts, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the circle concept.

Introduction

Thinking skill is one essential factor of students' success in learning mathematics. It is helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, & Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). Low order thinking skill consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). Higher order thinking skill consists of three most top cognitive domains of Bloom Taxonomy (analysis, evaluation, and creation) (Tanujaya, Mumu, &

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Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & TanikOnal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities which constructing the meaning or concept based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding learned by integrating new insight into the knowledge that already have (Marcelo & Yot-Domínguez, 2019). Students will understand the concept when constructing the meaning from instructional messages (Russ, 2018). So, understanding is learning by construct definition by integrating new insight with prior knowledge.

Several studies have been conducted to support students' understanding by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) used the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, Nurdiansyah and Prahmana (2017) use the IRME approach through a glass context that can help students learn the concept of the circle's circumference. The research is an example of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle.

IRME approach is considered capable of support students in understanding mathematical concepts. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, & Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, & Visnovska, 2008).

The students with strong conceptual knowledge are likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students' difficulty understanding the concept of a circle (Rejeki & Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study would like to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research provides an alternative framework as a starting point for learning circles using daily activities that close to students.

Research Methods

The research method used in this study is design research. In design research, an intervention (such as programs, strategies, and materials) for teaching and learning is designed to solve a problem to address in education (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, the design research method helps to determine which activities have been designed to support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The participants were eight-grade students which consisted of 12 male students and eight female students. There were three stages in this design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary design

The preliminary design phase formulated the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer & Cobb, 2006). There were three activities in this phase. Firstly, is choosing a teacher who teaches in the learning process. Secondly, is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly, obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information used to design the Hypothetical Learning Trajectory (HLT), which consists of three components, namely a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Activity	**Main goal**	**Conjecture**
Assembling the Ferris wheel	Figure out the parts of the Ferris wheel	▪ Students collect the information about the Ferris wheel first and then make it ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determine the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Complete the table by drawing and define the part of the circle	▪ Students fill all tables correctly ▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly

Solving a problem related to the parts of the circle	Determine the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determine the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase was divided into two cycles, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group of six students who chosen purposively. The purpose of this phase was to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle implemented in this second cycle. The second cycle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Retrospective analysis

After conducting a teaching experiment, all the collected data analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory became a guide in analyzing the collected data. It allowed to investigate and explain how students understood the concept of the circle. Video recording was the primary data needed to answer research questions. The video showed students learning activities and group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principles explaining how and why the design will works. Therefore, the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

Results and Discussion

This research developed a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consisted of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher started the lesson by asking students about the amusement park. The teacher asked questions to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in dialogue 1.

Dialogue 1.

Teacher	:	*Have you ever visited an amusement park?*
Students	:	*Yes, I have.*
Teacher	:	*What are the rides in there? Can you mention it?*
Students	:	*Kora-kora, kurungan manuk, haunted house, boom boom car, carousel, tong stand.*
Teacher	:	*How about a Ferris wheel? Have you ever ridden that?*
Student 1	:	*Yes, I have.*
Student 2	:	*What is a Ferris wheel?*

Based on dialogue 1, some students did not know about the Ferris wheel. Even though both of them, *kurungan manuk* and Ferris wheel, are the same thing. The teacher introduces the Ferris wheel context that would be used as a starting point in the learning process. The existence of the student worksheet and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, & Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu park so that students have the same perception about the Ferris wheel. The student and teacher's understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in dialogue 2.

Dialogue 2.

Teacher	:	*It is a Ferris wheel at Sindu Kusuma Edu park.*
Students	:	*It is kurungan manuk (Ferris wheel in the Javanese language)*
Teacher	:	*Both of them are the same. Can you mention the part of the Ferris wheel?*
Students	:	*The wheel of a circle, a wheel spoke, kurungan manuk (a cabin).*

Dialogue 2 shows that most students are familiar with the term *kurungan manuk* (Javanese language) compared to the term "Ferris wheel". After watching the video, students know that the Ferris wheel is another name for the *kurungan manuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. Students receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, students try to assemble a

Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively can help students' understanding a mathematical concept. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

The use of something that related or closed to student, such as the Ferris wheel, in the learning process, is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel. It means that the Ferris wheel is a context in this learning activity.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. The student worksheet describes that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Furthermore, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with the results of the study of Alberghi et al. (2013) which states that most students will not be able to draw a circle without using several supporting equipment. Group 2 and Group 5 using the bottle caps to draw the circle. Group 4 drawing the circle by using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity demonstrated another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, they found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students spinned the wheel so that the red cabin was at the top of the wheel. They drew an illustration of a cabin showing the positions of four passengers, as shown in Figure 3. This illustration will be used in the next activities.

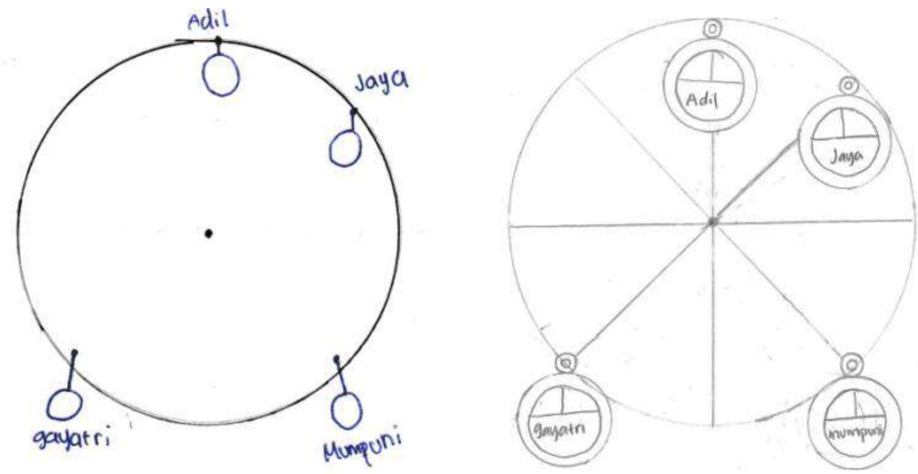
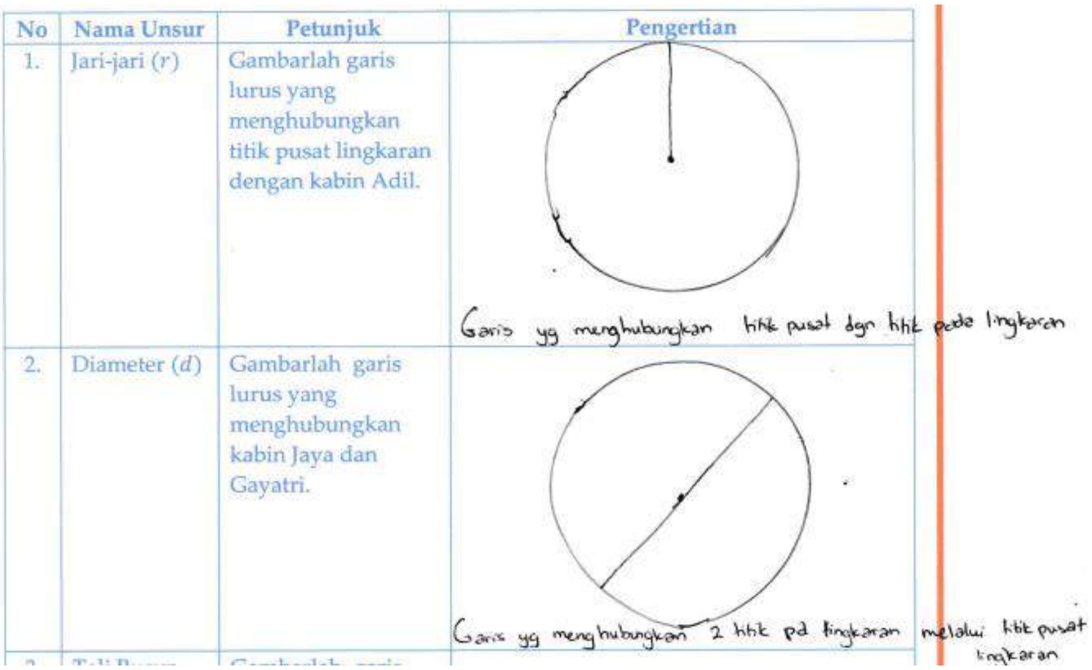


Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity involved students making a list of the parts of the circle. The students completed the table on the worksheet. In this activity, students discussed with their members of their group the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). Students retained the mathematical concept and recall faster their knowledge by group discussion. This result is supported by Chianson, Kurumeh, and Obida (2010) who explains that cooperative learning that focuses on group discussion can influence students' understanding of a mathematical concept faster.

Group 2 completed all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	Nama Unsur	Petunjuk	Pengertian
1.	Jari-jari (r)	Gambarlah garis lurus yang menghubungkan titik pusat lingkaran dengan kabin Adil.	Garis yg menghubungkan titik pusat dgn titik pada lingkaran
2.	Diameter (d)	Gambarlah garis lurus yang menghubungkan kabin Jaya dan Gayatri.	Garis yg menghubungkan 2 titik pd lingkaran melalui titik pusat lingkaran

No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle
2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.

3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of a chord of a circle

The teacher's role was to guide the students by giving clues. She gives a clue in the form of student worksheets and questions during the discussion process that serves to guide students in finding a part of circle concept. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in dialogue 3.

Dialogue 3.

Teacher	:	*Which one is a chord of a circle? Can you show it to me?*
Students	:	*It is a chord (*said student while pointing at the picture they've made*
Teacher	:	*The instruction on the worksheet is drawing a straight line connecting the Jaya and Mumpuni cabins. Can you show me, where is the Jaya cabin and Mumpuni cabin?*
Students	:	*Right here and here (*student pointing the Jaya cabin and Mumpuni cabin.*
Teacher	:	*So, which one is a chord of a circle? Can you draw it?*
Students	:	*(*students draw a chord base on clues given by the teacher*

After getting some clue from the teacher, they re-drew a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil cabin (red cabin). Second, they draw a line connecting the center point to Jaya cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.

1	Sector of a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" The area bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

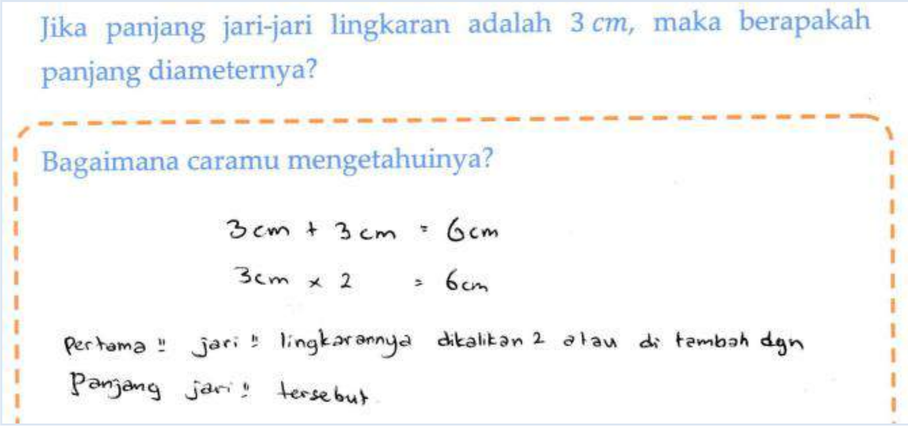
The teacher provided clues to Group 4 (interactivity) so that they could define a sector. This activity provided a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in dialogue 4.

Dialogue 4.

Students	:	*What is the sector?*
Teacher	:	*Which one a sector of a circle. Can you show it to me?*
Students	:	*This one. The shaded area.*
Teacher	:	*Very good. So, it is bounded by ...*
Students	:	*Emm... this line and also this one*
Teacher	:	*What is it called?*
Students	:	*Radius and arc.*
Teacher	:	*How many it has?*
Students	:	*There are two.*
Teacher	:	*So, what is the sector?*
Students	:	*The sector is an area bounded by two radius and an arc.*

Solving problems related to the parts of the circle

In this activity, students were asked to solve problems related to the parts of the circle. First, students are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplied the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.



If the length of the radius of the circle is 3 cm, what is the length of the diameter?

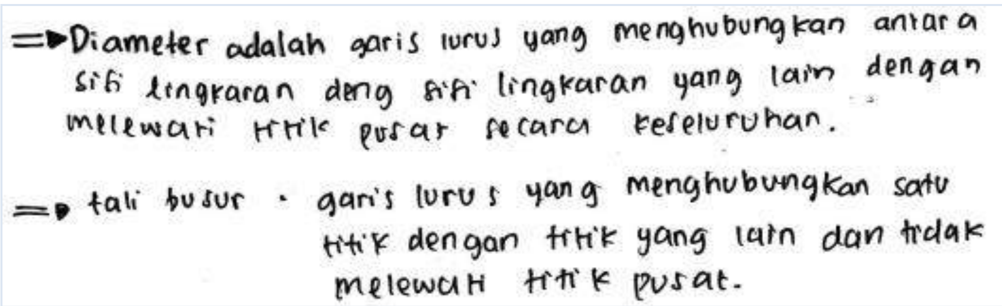
How do you know?

3 cm + 3 cm = 6 cm
3 cm x 2 = 6 cm

Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on the table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).

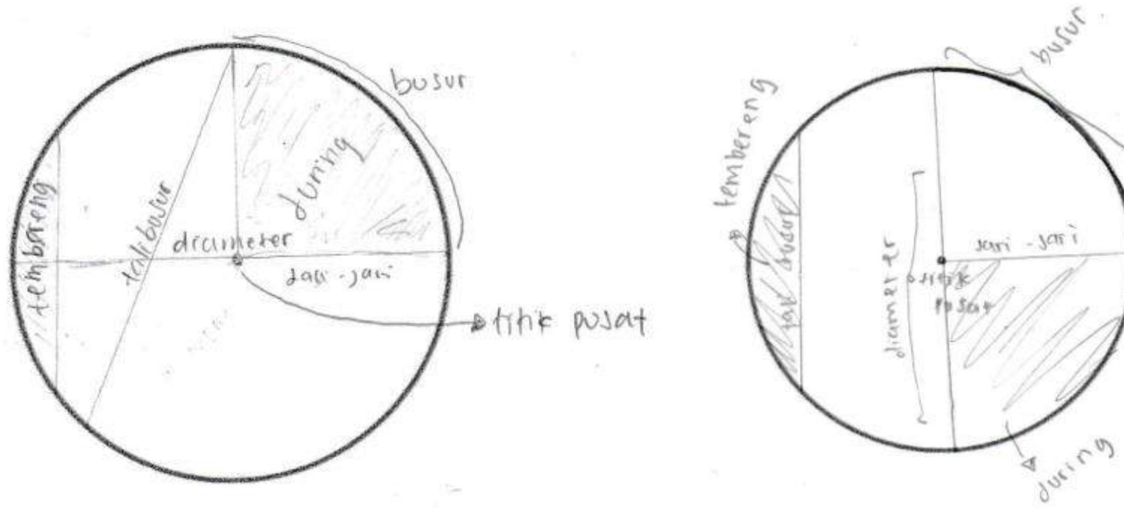


The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole

a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Tembereng = segment
Tali busur = chord
Diameter = diameter
Juring = sector

Jari-jari = radius
Titik pusat = center point
Busur = arc

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be given by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students showed that, overall, the average score of the students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students had understood the concepts related to the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani & Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah & Prahmana, 2017; Rejeki & Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle in four activities. Firstly, in the informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Secondly, students can draw an illustration of four passengers in the Ferris wheel. Thirdly, students are making a list of the parts of the circle. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord.

The study's results can be used to implement a learning trajectory that has been designed more broadly. It can also be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of circles.

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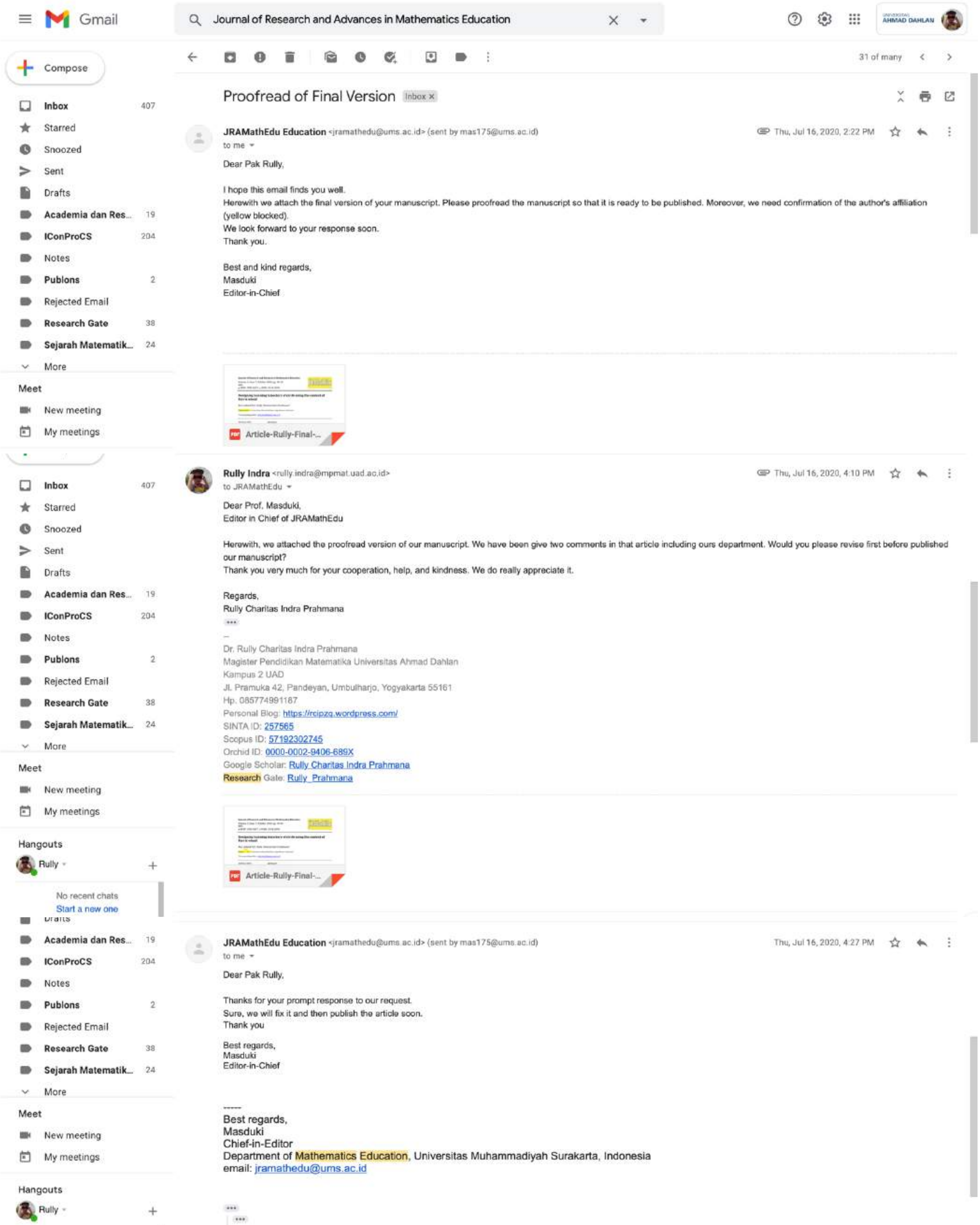
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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. Many students are familiar with the Ferris wheel in the mini version of it at night market festivals. This is the potential for learning mathematics. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) where students learn with contexts which are close to students' life as starting points. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning about circles. The research method is design research that consists of three stages: preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the circle parts, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the concept of a circle.

Introduction

Thinking skill is one essential factor of students' success in learning mathematics. It is helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, & Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). The LOTS consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). Furthermore, the HOTS have three most top cognitive domains of Bloom Taxonomy (analysis, evaluation, and creation) (Tanujaya, Mumu, & Margono, 2017).

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However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & TanikOnal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities that construct the meaning or concept based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learned by integrating new insight into the knowledge already has (Marcelo & Yot-Domínguez, 2019). Students will understand the concept when they construct the meaning from instructional messages (Russ, 2018). So, understanding is learned by construct definition trough integrated new insight with prior knowledge.

Several studies have been conducted to support students' understanding by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) use the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, the context of glass in the RME approach also can help students learn the concept of the circle's circumference (Nurdiansyah & Prahmana, 2017). These researches are several examples of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle at junior high school.

IRME approach is considered capable of support students in understanding mathematical concepts. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, & Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, & Visnovska, 2008).

The students with strong conceptual knowledge are likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students are difficulty understanding the concept of a circle (Rejeki & Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study would like to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research provides an alternative framework as a starting point for learning circles using daily activities that close to students.

Research Methods

The research method used in this study is design research. In design research, an intervention (such as programs, strategies, and materials) for teaching and learning is designed to solve a problem to address in education (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, the design research method helps to determine which activities have been designed to support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The participants were eight-grade students which consisted of 12 male students and eight female students. There were three stages in this design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary design

The preliminary design phase formulated the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer & Cobb, 2006). There were three activities in this phase. First is choosing a teacher who teaches in the learning process. Second is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly is obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information is used to design the Hypothetical Learning Trajectory (HLT), which consists of three components: a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figuring out the parts of the Ferris wheel	▪ Students collect the information about the Ferris wheel first and then make it ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determining the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Completing the table by drawing and define the part of the circle	▪ Students fill all tables correctly ▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly

Table 1
Continue

Activity	Main goal	Conjecture
Solving a problem related to the parts of the circle	Determining the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determining the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase was divided into two cycles, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group of six students who chosen purposively. The purpose of this phase was to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle was implemented in this second cycle. The second cycle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Retrospective analysis

After conducting a teaching experiment, all the collected data were analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory became a guide in analyzing the collected data. It allowed to investigate and explain how students understood the concept of the circle. Video recording was the primary data needed to answer research questions. The videos show the students' learning activities and also the students' group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principles explaining how and why the design will work. Therefore, the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

Results and Discussion

This research developed a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consisted of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher started the lesson by asking students about the amusement park. The teacher asked questions to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in Dialogue 1.

Dialogue 1.

Teacher	:	Have you ever visited an amusement park?
Students	:	Yes, I have.
Teacher	:	What are the rides in there? Can you mention them?
Students	:	Kora-kora, *kurungan manuk*, haunted house, boom boom car, carousel, tong stand.
Teacher	:	How about a Ferris wheel? Have you ever ridden that?
Student 1	:	Yes, I have.
Student 2	:	What is a Ferris wheel?

Based on Dialogue 1, some students did not know about the Ferris wheel. Even though both of *kurungan manuk* or Ferris wheel are the same thing. The teacher introduces the Ferris wheel context that would be used as a starting point in the learning process. The existence of the student worksheet and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, & Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu Park so that students have the same perception about the Ferris wheel. The student's and teacher's understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in Dialogue 2.

Dialogue 2.

Teacher	:	It is a Ferris wheel at Sindu Kusuma Edupark.
Students	:	It is *kurungan manuk* (Ferris wheel in the Javanese language)
Teacher	:	Both of them are the same. Can you mention the part of the Ferris wheel?
Students	:	The wheel of a circle, a wheel spoke, *kurungan manuk* (a cabin).

Dialogue 2 shows that most students are familiar with the term *kurungan manuk* (Javanese language) compared to the term "Ferris wheel". After watching the video, students know that the Ferris wheel is another name for the *kurungan manuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. They receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, they try to assemble a Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively can help students' understanding a mathematical concept. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

The use of something that related or closed to student, such as the Ferris wheel, in the learning process, is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel. It means that the Ferris wheel is a context in this learning activity.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. The student worksheet describes that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Furthermore, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with the results of the study of Alberghi et al. (2013) which states that most students will not be able to draw a circle without using several supporting equipment. Groups 2 and 5 used the bottle caps to draw the circle. Group 4 drew the circle using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity demonstrated another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, they found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students spin the wheel so that the red cabin was at the top of the wheel. They drew an illustration of a cabin showing the positions of four passengers, as shown in Figure 3. This illustration will be used in the next activities.

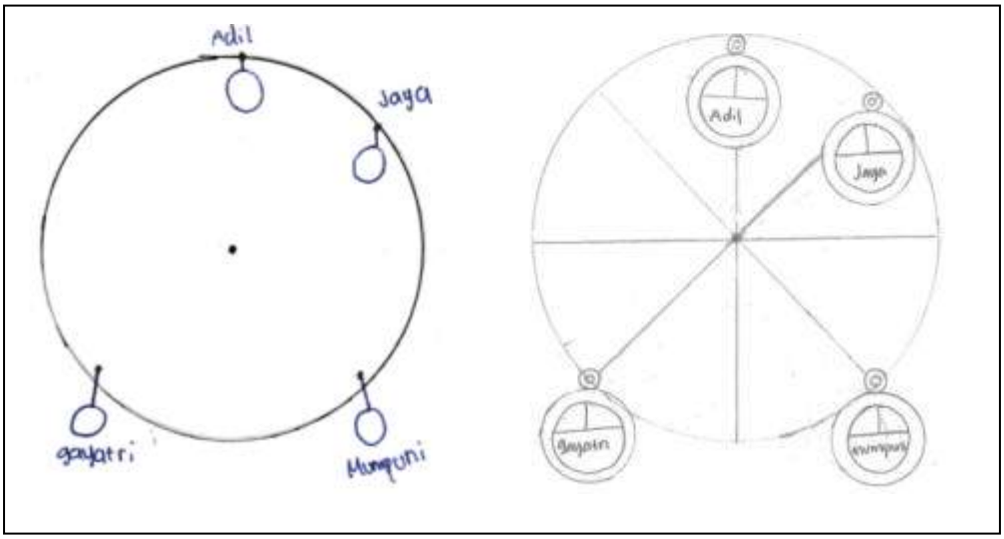
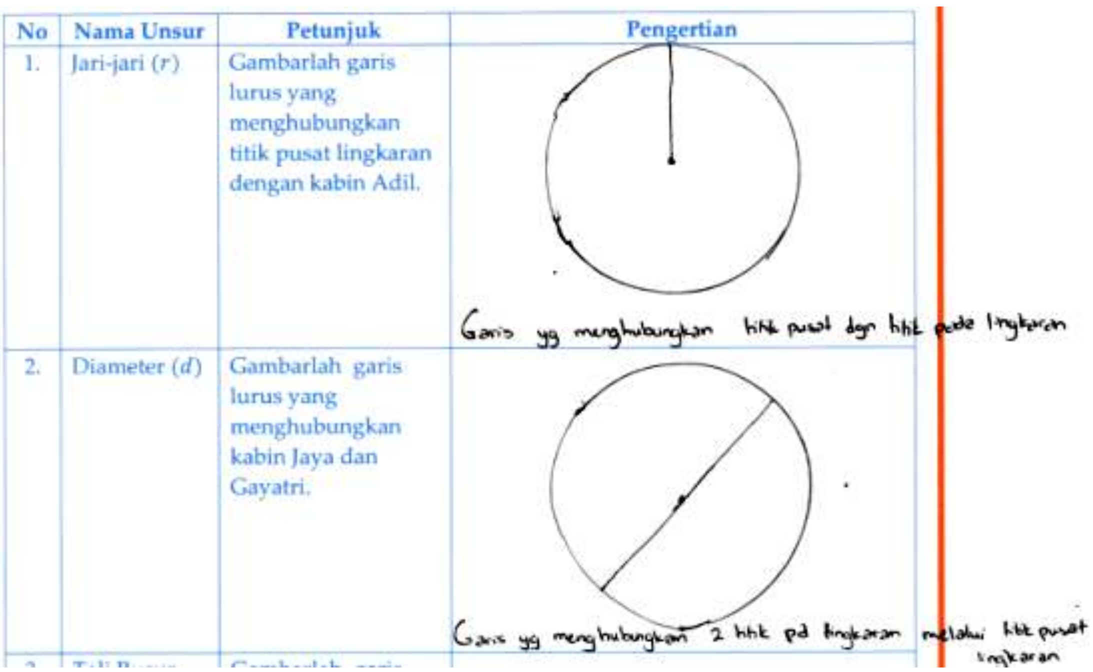


Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity involved students making a list of the parts of the circle. They completed the table on the worksheet. In this activity, students discussed with their members of their group the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). They retained the mathematical concept and recall faster their knowledge by group discussion. This result is supported by Chianson, Kurumeh, and Obida (2010) who explains that cooperative learning that focuses on group discussion can influence students' understanding of a mathematical concept faster.

Group 2 completed all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



No	Nama Unsur	Petunjuk	Pengertian
1.	Jari-jari (r)	Gambarlah garis lurus yang menghubungkan titik pusat lingkaran dengan kabin Adil.	Garis yg menghubungkan titik pusat dgn titik pada lingkaran
2.	Diameter (d)	Gambarlah garis lurus yang menghubungkan kabin Jaya dan Gayatri.	Garis yg menghubungkan 2 titik pd lingkaran melalui titik pusat lingkaran

Translation:

No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle
2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.

Translation:

3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of a chord of a circle

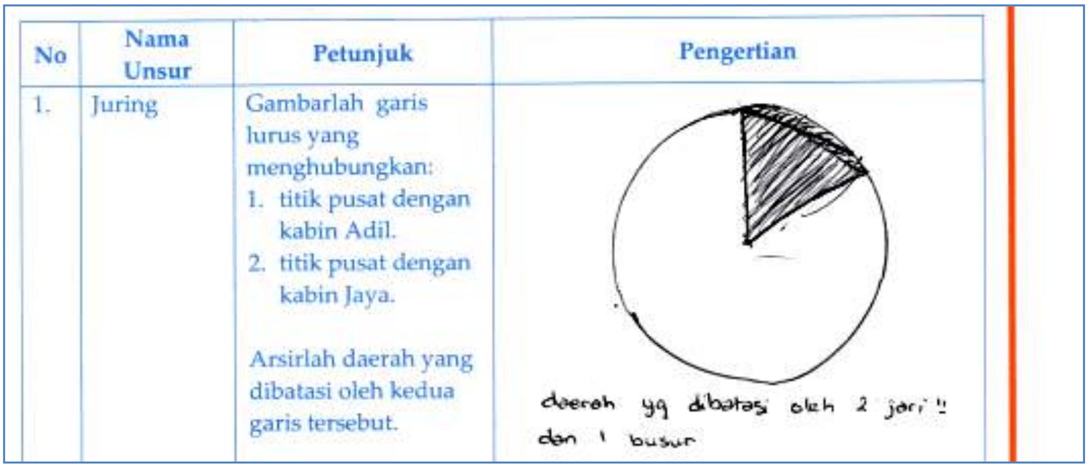
The teacher's role was to guide the students by giving clues. She gives a clue in the form of student worksheets and questions during the discussion process that serves to guide students in finding a part of circle concept. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in Dialogue 3.

Dialogue 3.

Teacher	:	Which one is a chord of a circle? Can you show it to me?
Students	:	It is a chord (*said student while pointing at the picture they've made
Teacher	:	The instruction on the worksheet is drawing a straight line connecting the Jaya's and Mumpuni's cabins. Can you show me, where is the Jaya's and Mumpuni's cabin?
Students	:	Right here and here (*student pointing the Jaya's and Mumpuni's cabin).
Teacher	:	So, which one is a chord of a circle? Can you draw it?
Students	:	(*students draw a chord base on clues given by the teacher)

After getting some clue from the teacher, they re-drew a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil's cabin (red cabin). Second, they draw a line connecting the center point to Jaya's cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.



No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari" dan 1 busur

Translation:

1	Sector of a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" The area bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

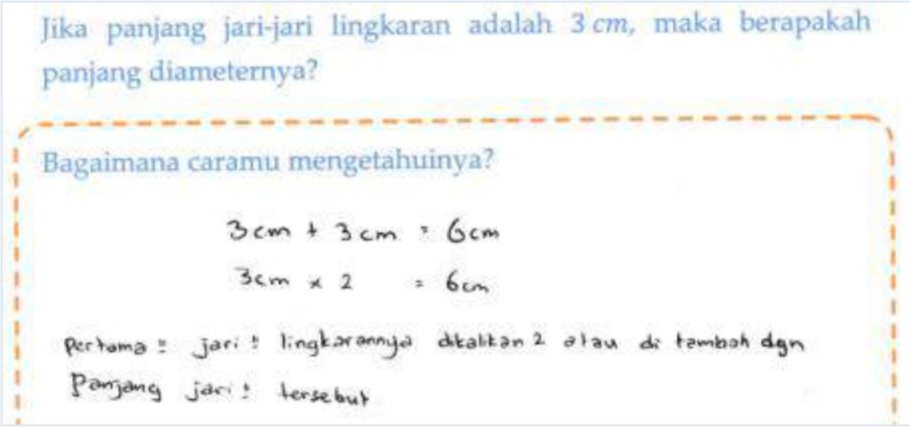
The teacher provided clues to Group 4 (interactivity) so that they could define a sector. This activity provided a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in Dialogue 4.

Dialogue 4.

Students : What is the sector?
Teacher : Which one a sector of a circle. Can you show it to me?
Students : This one. The shaded area.
Teacher : Very good. So, it is bounded by ...
Students : Emm… this line and also this one
Teacher : What is it called?
Students : Radius and arc.
Teacher : How many it has?
Students : There are two.
Teacher : So, what is the sector?
Students : The sector is an area bounded by two radius and an arc.

Solving problems related to the parts of the circle

In this activity, students were asked to solve problems related to the parts of the circle. First, they are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplied the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.



Translation:

If the length of the radius of the circle is 3 cm, what is the length of the diameter?

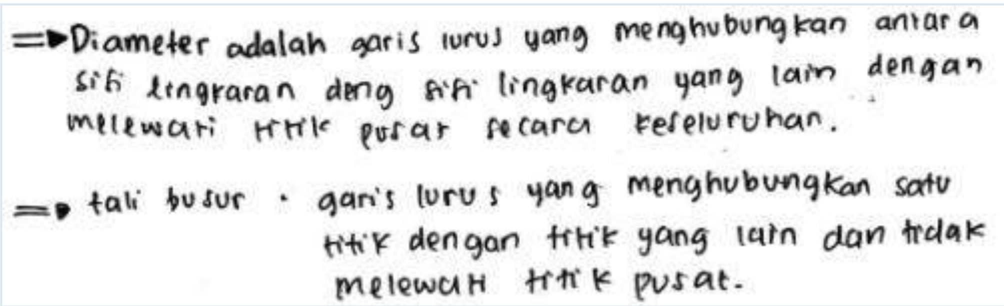
How do you know?

3 cm + 3 cm = 6 cm
3 cm x 2 = 6 cm

Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).



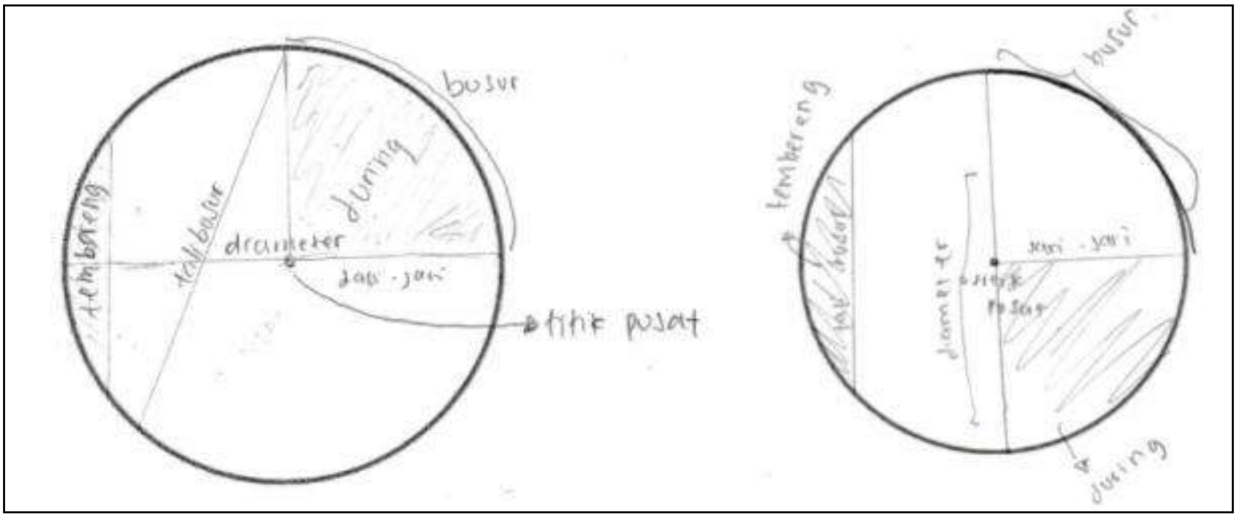
Translation:

The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole

a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Translation:

Tembereng = segment	*Jari-jari* = radius
Talibusur = chord	*Titikpusat* = center point
Diameter = diameter	*Busur* = arc
Juring = sector	

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be taken by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students showed that, overall, the average score of the students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students had understood the concepts related to the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani & Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah & Prahmana, 2017; Rejeki & Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle in four activities. Firstly, in the informal stage, they are introduced to a circle through a Ferris wheel in an amusement park. Secondly, students can draw an illustration of four passengers in the Ferris wheel. Thirdly, students are making a list of the parts of the circle. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord. Furthermore, the study's results can be used to implement a learning trajectory that has been designed more broadly. It can also be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of circles.

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Designing learning trajectory of circle using the context of Ferris wheel

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Abstract

Ferris wheel is one amusement playground that resembles a giant spinning wheel. Many students are familiar with the Ferris wheel in the mini version of it at night market festivals. This is the potential for learning mathematics. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) where students learn with contexts which are close to students' life as starting points. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning about circles. The research method is design research that consists of three stages: preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the circle parts, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the concept of a circle.

Keywords

Circle, Design Research, Ferris Wheel, Indonesian Realistic Mathematics Education

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Designing learning trajectory of circle using the context of Ferris wheel

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ABSTRACT

Ferris wheel is one amusement playground that resembles a giant spinning wheel. Many students are familiar with the Ferris wheel in the mini version of it at night market festivals. This is the potential for learning mathematics. Furthermore, there is a mathematical learning approach called Indonesian Realistic Mathematics Education (IRME) where students learn with contexts which are close to students' life as starting points. Therefore, this study aims to design a learning trajectory using the IRME approach with the Ferris wheel as the context in the learning process to support students' understanding of the learning about circles. The research method is design research that consists of three stages: preliminary design, design experiments, and retrospective analysis. The subjects were 20 eighth-grade students from one of the private Junior High School in Yogyakarta. The instruments used are videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The research result explores the learning trajectory practiced using the Ferris wheel as the context seen in the student's daily activities. The learning trajectory consists of four events, namely assembling the Ferris wheel, drawing an illustration of the Ferris wheel, making a list of the circle parts, and solving a problem related to the parts of the circle. Lastly, this study shows that learning trajectory activities have essential roles in supporting students' understanding of the concept of a circle.

Introduction

Thinking skill is one essential factor of students' success in learning mathematics. It is helpful for students to solve problems (Budiarti, Suparmi, Sarwanto, & Harjana, 2017; Hwang & Chen, 2017). Thinking skills can be divided into two parts, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS) (Ahmad et al., 2017; Abdullah et al., 2016). The LOTS consists of three essential cognitive domains of Bloom Taxonomy (remember, understand, and apply) (Tarman & Kuran, 2015; Kozikoğlu, 2018; Verdina & Gani, 2018). Furthermore, the HOTS have three most top cognitive domains of

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Bloom Taxonomy (analysis, evaluation, and creation) (Tanujaya, Mumu, & Margono, 2017). However, the existence of these levels does not mean that LOTS is not essential (Erol, Buyuk, & TanikOnal, 2016; Apino & Retnawati, 2017). The basic level must be achieved first to move up at the highest level.

Understanding is one of the three basic level capabilities that construct the meaning or concept based on prior knowledge (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017; McCarthy & Goldman, 2019). Furthermore, understanding is learned by integrating new insight into the knowledge already has (Marcelo & Yot-Domínguez, 2019). Students will understand the concept when they construct the meaning from instructional messages (Russ, 2018). So, understanding is learned by construct definition trough integrated new insight with prior knowledge.

Several studies have been conducted to support students' understanding by designing the learning trajectory using the Indonesian Realistic Mathematics Education (IRME) approach. The approach uses context as a starting point that can help students understand the concept of a circle. Rejeki and Putri (2018) use the IRME approach through tiled settings to help students learning the idea of the area of a circle. In line with this finding, the context of glass in the RME approach also can help students learn the concept of the circle's circumference (Nurdiansyah & Prahmana, 2017). These researches are several examples of the implementation of the IRME approach at junior high school. Therefore, IRME is considered capable of supporting students' understanding of the concept of the circle at junior high school.

IRME approach is considered capable of support students in understanding mathematical concepts. IRME was adapted from the RME (Realistic Mathematics Education) theory developed by Hans Freudenthal in the Netherlands (Prahmana, Zulkardi, & Hartono, 2012). This approach can be used to improve students' understanding of mathematical concepts (Laurens, Batlolona, Batlolona, & Leasa, 2017). IRME approach allows students to discover their mathematical concepts under the teacher (Cobb, Zhao, & Visnovska, 2008).

The students with strong conceptual knowledge are likely to continue to learn more because their prior experience makes it easier for them to process and use information related to the topic (Booth, 2011). But the fact, most students are difficulty understanding the concept of a circle (Rejeki & Putri, 2018). Students difficulty determining the center point and the radius of the circle (Akyuz, 2016; Lee & Yun, 2018). It happens because the learning process emphasizes memorizing formulas rather than understanding the concepts (Indriani & Julie, 2017; Rejeki & Putri, 2018). However, the circle becomes essential for learning another geometry topic, such as a sphere.

Alberghi, Resta, and Gaudenzi (2013) have experience in teaching many samples of curves such as parabolas, clothoid, and straight using amusement park as a context. They said an amusement park is a beautiful place where conics become visible and closer to the students' previous experience, so that learning mathematics involves experimenting models on the field, and where amusement and learning do successfully join together. On the other hand, the Ferris wheel is one of the amusement playgrounds that resembles a giant spinning wheel containing mathematical elements used in the circle's learning. Therefore, this study would like to design the learning trajectory of the parts of a circle using the Ferris wheel context for eighth-grade students. This research provides an alternative framework as a starting point for learning circles using daily activities that close to students.

Research Methods

The research method used in this study is design research. In design research, an intervention (such as programs, strategies, and materials) for teaching and learning is designed to solve a problem to address in education (Bakker, 2018). It becomes an alternative solution to answer the research question and know about the students learning process. Also, the design research method helps to determine which activities have been designed to support students' understanding of the concept of a circle. This research took place in one of the private Junior High School in Yogyakarta. The participants were eight-grade students which consisted of 12 male students and eight female students. There were three stages in this design research, namely preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary design

The preliminary design phase formulated the learning trajectory elaborated and refined in the experimental design phase (Gravemeijer & Cobb, 2006). There were three activities in this phase. First is choosing a teacher who teaches in the learning process. Second is preparing the learning activities through a literature review about the concept of the circles using the Ferris wheel and the Indonesian Realistic Mathematics Education (IRME) approach. Lastly is obtaining information about students' difficulties in learning circles and the activities that can support students' understanding of circles concept. This information is used to design the Hypothetical Learning Trajectory (HLT), which consists of three components: a learning goal, a set of the learning task, and a hypothesized learning process (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The hypothesized learning process, namely conjecture, serves as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the design experiment phase. The overview of the activities and the conjecture of students thinking are described in Table 1.

Table 1
The overview of the activities and conjecture of the learning process

Activity	Main goal	Conjecture
Assembling the Ferris wheel	Figuring out the parts of the Ferris wheel	▪ Students collect the information about the Ferris wheel first and then make it ▪ Students confuse to rearrange the cabin
Drawing an illustration of the Ferris wheel	Determining the center point of the circle	▪ Students draw the circle using or without equipment ▪ Students bring the center point directly ▪ Students draw two intersecting lines then mark the intersection points ▪ Students fold the paper into equal parts and then score the intersection points
Making a list the parts of the circle	Completing the table by drawing and define the part of the circle	▪ Students fill all tables correctly ▪ Students fill in some of the tables correctly ▪ Students cannot fill all tables correctly

Table 1
Continue

Activity	Main goal	Conjecture
Solving a problem related to the parts of the circle	Determining the relationship between radius and diameter	▪ Students can determine the relationship between the length of the radius and the diameter ▪ Students are less able to identify the radius and diameter in the previous activity, so they cannot determine the relationship between both of them
	Determining the difference between diameter and chord	▪ Students can determine the difference in diameter and chord ▪ Students are less able to identify the diameter and music in the previous activity, so they cannot determine the difference between both of them

Design experiment

This phase was divided into two cycles, namely teaching experiment and pilot experiment. In the teaching experiment, the HLT that has been designed in the previous step is implemented in a small group of six students who chosen purposively. The purpose of this phase was to explore and observe the students' strategies and understanding during the learning process. Furthermore, HLT is revised and improved based on the advice of the evaluation in the first phase. The revised HLT in the first cycle was implemented in this second cycle. The second cycle, namely pilot experiment, conducted in the natural classroom setting. The data were collected through classroom observation by video recording and students' worksheets to answer the research questions. Lastly, the group discussion's documentation recorded is to describe the students' understanding during the learning process.

Retrospective analysis

After conducting a teaching experiment, all the collected data were analyzed in this phase by comparing the conjecture in HLT designed in the first stage with the implementing results of learning trajectory. Furthermore, the role of the learning trajectory became a guide in analyzing the collected data. It allowed to investigate and explain how students understood the concept of the circle. Video recording was the primary data needed to answer research questions. The videos show the students' learning activities and also the students' group discussions. Wijaya (2008) explains that the design research result is not design that works but the underlying principles explaining how and why the design will work. Therefore, the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of circle generated from the Ferris wheel context.

Results and Discussion

This research developed a learning trajectory in the parts of the circle through several learning activities for eighth-grade students. The learning activities consisted of four activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

The teacher started the lesson by asking students about the amusement park. The teacher asked questions to clarify students' knowledge about the Ferris wheel as the context that will be used in the learning process. Students can mention many kinds of amusement ride, as seen in Dialogue 1.

Dialogue 1.

Teacher	:	Have you ever visited an amusement park?
Students	:	Yes, I have.
Teacher	:	What are the rides in there? Can you mention them?
Students	:	Kora-kora, *kurungan manuk*, haunted house, boom boom car, carousel, tong stand.
Teacher	:	How about a Ferris wheel? Have you ever ridden that?
Student 1	:	Yes, I have.
Student 2	:	What is a Ferris wheel?

Based on Dialogue 1, some students did not know about the Ferris wheel. Even though both of *kurungan manuk* or Ferris wheel are the same thing. The teacher introduces the Ferris wheel context that would be used as a starting point in the learning process. The existence of the student worksheet and exercise material used has a positive impact on stimulating students to think, communicate, and collaborate in the learning process (Yono, Zulkardi, & Nurjannah, 2019). Furthermore, the teacher shows a video about the Ferris wheel in the Sindu Kusuma Edu Park so that students have the same perception about the Ferris wheel. The student's and teacher's understanding about the context, namely the Ferris wheel used, can facilitate the teaching and learning process more insightful (Alberghi et al., 2013; Stevens & Moore, 2016). For more details, it can be seen in Dialogue 2.

Dialogue 2.

Teacher	:	It is a Ferris wheel at Sindu Kusuma Edupark.
Students	:	It is *kurungan manuk* (Ferris wheel in the Javanese language)
Teacher	:	Both of them are the same. Can you mention the part of the Ferris wheel?
Students	:	The wheel of a circle, a wheel spoke, *kurungan manuk* (a cabin).

Dialogue 2 shows that most students are familiar with the term *kurungan manuk* (Javanese language) compared to the term "Ferris wheel". After watching the video, students know that the Ferris wheel is another name for the *kurungan manuk*. Furthermore, students understand the parts of the Ferris wheel, such as a wheel, cabins, and a wheel spoke. Therefore, the teacher has an essential role in introducing the context.

Next, the teacher informs about the learning goal that must be achieved by students, which is identifying the parts of the circle. It also tells the students about the learning activities such as group discussions and presentations. The teacher asks students to sit in groups. One group consists of 4 students. They receive worksheets from the teacher that contains several activities.

Assembling a Ferris wheel

In this informal stage, students are introduced to a circle through a Ferris wheel in an amusement park. Ferris wheel has a giant spinning wheel. Then, they try to assemble a Ferris wheel miniature according to the instructions given on the worksheet. The simulation in this part is one of how to work with mathematical content based on Ferris wheels in the digital culture of a teacher (Júnior, Alves, & de Moura, 2013).

Furthermore, there are four student activities to make the miniature of the Ferris wheel. First, cut all components of the Ferris wheel. Second, glue the bottom of the pole using a glue. Third, stick all the gear and cabin to the wheel (clockwise) in the order of color: red, orange, yellow, green, light blue, dark blue, purple, and pink. Lastly, pair the wheel to the pole using a push pin. This miniature has eight cabins with different colors. The position of the cabin can be adjusted by spinning the wheels. Stevens and Moore (2016) show that providing assignments to students who offer opportunities to reason quantitatively can help students' understanding a mathematical concept. In this case, making a Ferris wheel that can dynamically move instead of static encourages students to construct real situations, helping to promote their quantitative reasoning.

The use of something that related or closed to student, such as the Ferris wheel, in the learning process, is one of the characteristics of the IRME approach, namely the use of context. Figure 1 shows students are playing the Ferris wheel by spinning the wheel. It means that the Ferris wheel is a context in this learning activity.

Figure 1. Students spinning the wheel

Drawing an illustration of the Ferris wheel

In this activity, the teacher asks students to examine the problem on the worksheet. The student worksheet describes that four passengers ride the Ferris wheel with the position, Adil was in the red cabin, Jaya in the orange cabin, Mumpuni in the green booth, and Gayatri in the dark blue cabin. Students are asked to determine the center of the circle. Furthermore, they asked to draw the circle, which illustrated the position of the four passengers with the condition that the red cabin is at the top location. First, students are drawing the circle on the worksheet. The ways of students to draw the circle are different. Group 3 brings a circle immediately without equipment so that their sketch is imperfect.

Meanwhile, another group draws the circle using the equipment. This strategy is in line with the results of the study of Alberghi et al. (2013) which states that most students will not be able to draw a circle without using several supporting equipment. Groups 2 and 5 used the bottle caps to draw the circle. Group 4 drew the circle using the protractor.

Second, students discuss with their members of the group about the strategy to determine the center point. This activity demonstrated another characteristic of the IRME approach, namely using student contributions. Group 3 determines the center point by drawing the end directly without knowing the correct center point. Group 5 determines the center point by drawing two intersecting lines. Meanwhile, Group 4 determines the center of the circle by using a protractor. This strategy is appropriate with the conjecture of HLT. The groups use a ruler to ensure that the distance of the center point to the side of the circle is equal. However, they realize that their strategy cannot be used because the point is not necessarily located in the center of the circle. So, the teacher gives some clues to them. Furthermore, they found another strategy to determine the center of the circle by folding the paper into several pieces (Figure 2). Then, they draw the points at the intersection of the fold using a pencil.

Figure 2. Group 4 and Group 5 folding the paper to determine the center point

Lastly, students spin the wheel so that the red cabin was at the top of the wheel. They drew an illustration of a cabin showing the positions of four passengers, as shown in Figure 3. This illustration will be used in the next activities.

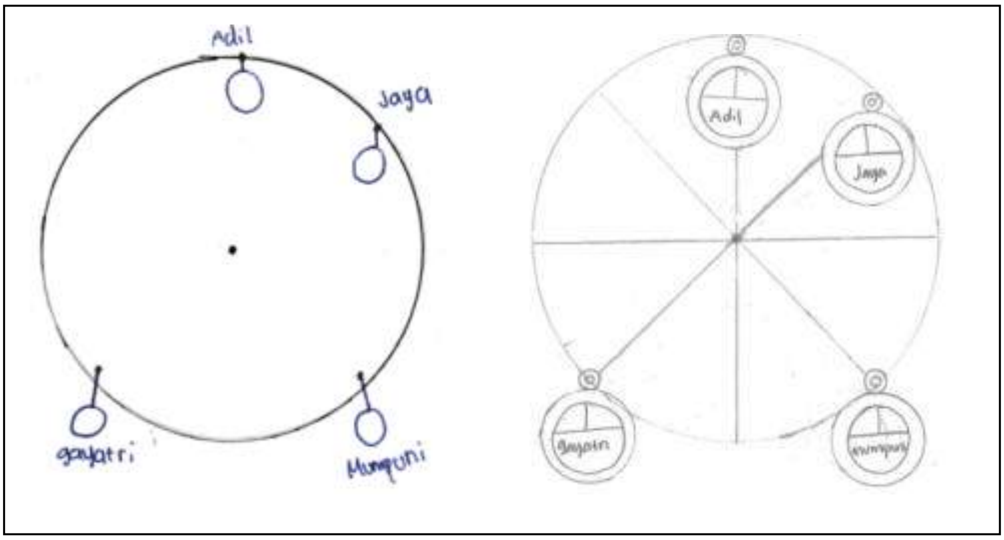
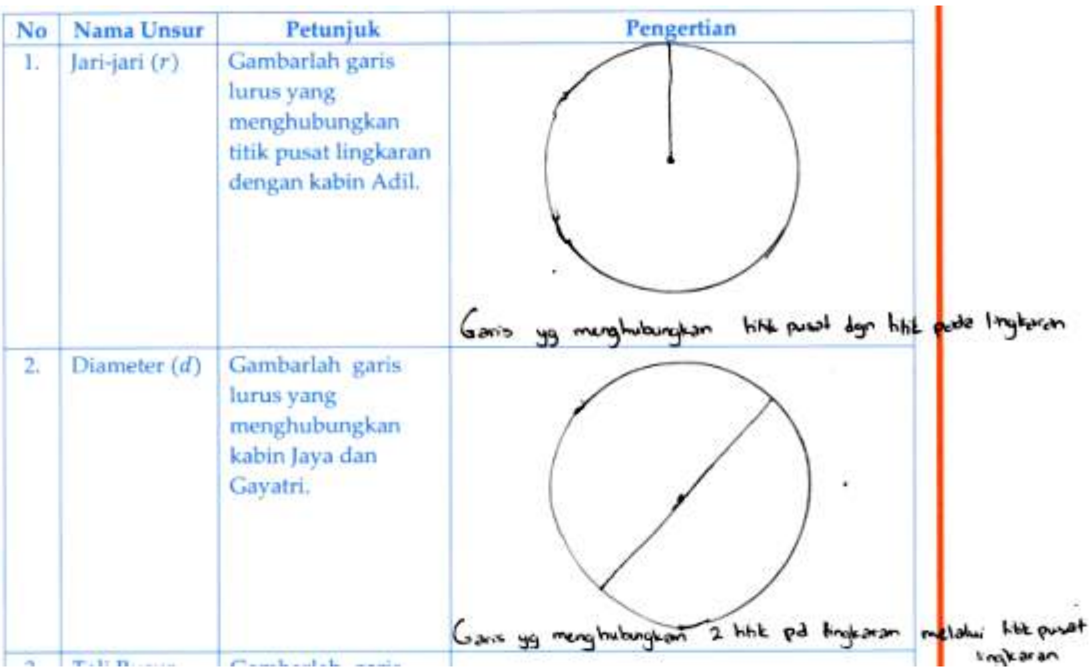


Figure 3. Group 4 and Group 5 draw an illustration of four passenger position

Making a list of the parts of the circle

The next activity involved students making a list of the parts of the circle. They completed the table on the worksheet. In this activity, students discussed with their members of their group the strategy to draw the parts of the circle according to the instructions given (model of) and define it (model for). They retained the mathematical concept and recall faster their knowledge by group discussion. This result is supported by Chianson, Kurumeh, and Obida (2010) who explains that cooperative learning that focuses on group discussion can influence students' understanding of a mathematical concept faster.

Group 2 completed all the tables correctly. First, they draw a circle and determine the center point using a folding strategy at the previous activity (intertwinement). Second, they bring a line connecting the center point to Adil cabin (red cabin). Based on their sketch, they describe a radius as a line connecting the center point with another location on the circle. Third, they draw a line connecting the Jaya cabin (orange cabin) and the Gayatri cabin (dark blue cabin). Furthermore, they define diameter as a line connecting two points on a circle and through the center point of the circle (Figure 4).



Translation:

No	The part names of circle	Instruction	Definition
1	Radius (r)	Draw a straight line connecting the center of the circle with the Adil's cabin	"Figure" A line connecting the center point with a point on the circle
2	Diameter (d)	Draw a straight line connecting the Jaya's cabin and Gayatri's cabin	"Figure" A line connecting two point on the circle through the center of circle

Figure 4. The part of the circle table task by group 2

As shown in Figure 5, Group 2 begins drawing a chord by drawing a straight line connecting the center point with Jaya and Mumpuni's cabin. They should bring a straight line that directly connects Jaya and Mumpuni's cabin.

Translation:

3	a chord of a circle	Draw a straight line connecting the Jaya's cabin and Mumpuni's cabin	"Figure" A line connecting two point on the circle

Figure 5. Group 2 draw an illustration of a chord of a circle

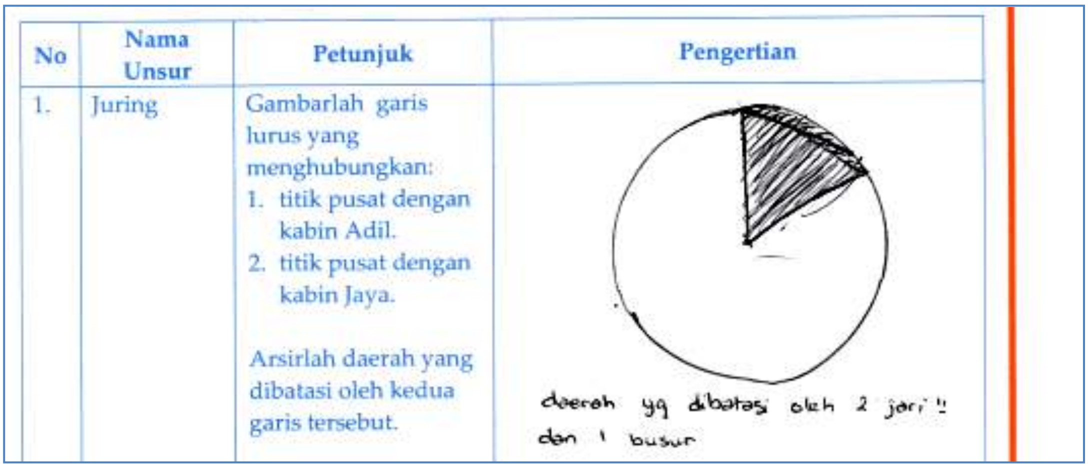
The teacher's role was to guide the students by giving clues. She gives a clue in the form of student worksheets and questions during the discussion process that serves to guide students in finding a part of circle concept. Bruce (2007) said that student interaction is foundational to deep understanding and related student achievement through classroom discussion and other interactive participation. The details of the discussion can be seen in Dialogue 3.

Dialogue 3.

Teacher	:	Which one is a chord of a circle? Can you show it to me?
Students	:	It is a chord (*said student while pointing at the picture they've made
Teacher	:	The instruction on the worksheet is drawing a straight line connecting the Jaya's and Mumpuni's cabins. Can you show me, where is the Jaya's and Mumpuni's cabin?
Students	:	Right here and here (*student pointing the Jaya's and Mumpuni's cabin).
Teacher	:	So, which one is a chord of a circle? Can you draw it?
Students	:	(*students draw a chord base on clues given by the teacher)

After getting some clue from the teacher, they re-drew a chord. They drew a line connecting Jaya's cabin (orange cabin) and Mumpuni's cabin (green cabin). Based on their sketch, they define a chord as a line connecting two points on a circle.

Group 4 understands the instructions thoroughly so they can draw a sector, as seen in Figure 6. First, they bring a line connecting the center point to Adil's cabin (red cabin). Second, they draw a line connecting the center point to Jaya's cabin (orange cabin). Lastly, they shaded the area bounded by both of line. But, they are difficult to define that. Therefore, the teacher's role is needed to help students.



No	Nama Unsur	Petunjuk	Pengertian
1.	Juring	Gambarlah garis lurus yang menghubungkan: 1. titik pusat dengan kabin Adil. 2. titik pusat dengan kabin Jaya. Arsirlah daerah yang dibatasi oleh kedua garis tersebut.	daerah yg dibatasi oleh 2 jari² dan 1 busur

Translation:

1	Sector of a circle	Draw a straight line connecting: 1. the center of circle with the Adil's cabin 2. the center of circle with the Jaya's cabin Shade the area bounded by these two lines	"Figure" The area bounded by two radius and one arc of circle

Figure 6. Group 4 complete the part of the circle table

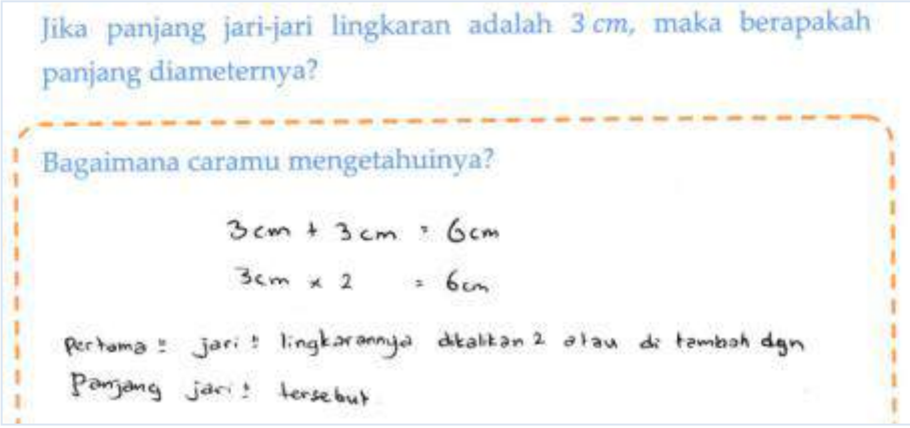
The teacher provided clues to Group 4 (interactivity) so that they could define a sector. This activity provided a deep understanding of students (Bruce, 2007). Next, group 4 represents a sector as the area bounded by two radii and one arc, as seen in Dialogue 4.

Dialogue 4.

Students	:	What is the sector?
Teacher	:	Which one a sector of a circle. Can you show it to me?
Students	:	This one. The shaded area.
Teacher	:	Very good. So, it is bounded by ...
Students	:	Emm… this line and also this one
Teacher	:	What is it called?
Students	:	Radius and arc.
Teacher	:	How many it has?
Students	:	There are two.
Teacher	:	So, what is the sector?
Students	:	The sector is an area bounded by two radius and an arc.

Solving problems related to the parts of the circle

In this activity, students were asked to solve problems related to the parts of the circle. First, they are asked to determine the length of the diameter by using a given radius. They discuss with their members of the group about the strategy to solve a problem. Based on the previous activity table, Group 2 understands that the length of the radius is half the length of the diameter. As seen in Figure 7, Group 2 multiplied the radius by two to determine the length of the diameter. If the length of the radius is 3 cm, then the length of the diameter is 2 × 3 = 6 cm.



Translation:

If the length of the radius of the circle is 3 cm, what is the length of the diameter?

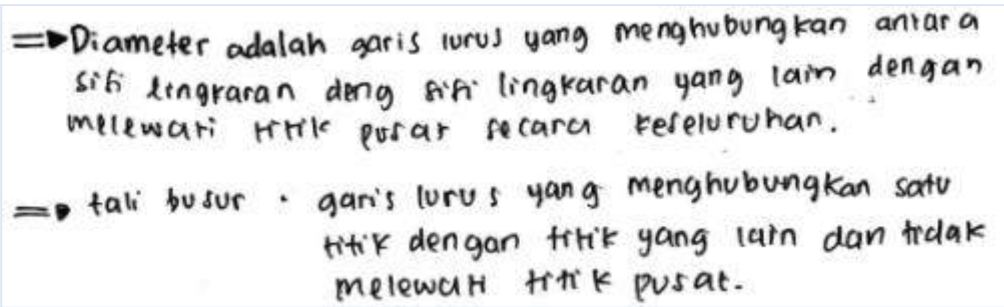
How do you know?

3 cm + 3 cm = 6 cm
3 cm x 2 = 6 cm

Firstly, the radius of the circle is multiplied by 2 or added to the length of the radius

Figure 7. Group 2 explain their answer

Second, students are asked to determine the difference in diameter and chord. Based on table in the previous activity, Group 4 explains that the diameter is a straight line that connects the side of the circle with the other side of the circle by passing through the center point of a circle. In contrast, the chord is a straight line that connects one location to another position and does not cross the center point (see in Figure 8).



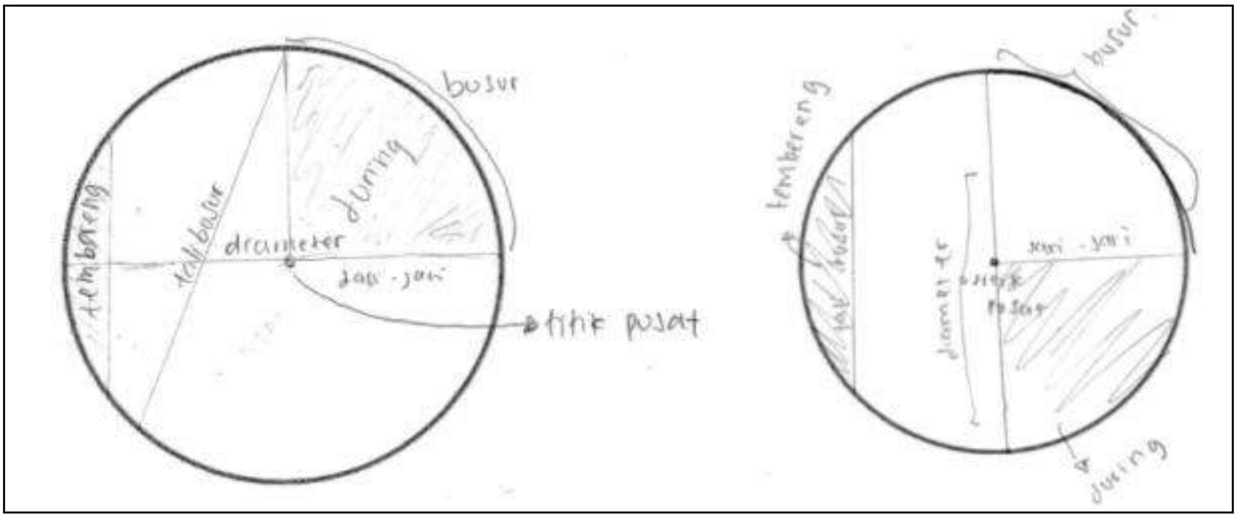
Translation:

The diameter is a straight line connecting between the side of the circle and the other side of the circle through the center of circle as a whole

a chord of a circle = straight line connecting one point to another point and does not cross the center point

Figure 8. Group 4 explain their answer

Lastly, students can identify the parts of the circle. Figure 9 shows that students can draw the part of the circle, such as center point, radius, diameter, arc, chord, sector, and segment.



Translation:

Tembereng = segment
Talibusur = chord
Diameter = diameter
Juring = sector

Jari-jari = radius
Titikpusat = center point
Busur = arc

Figure 9. Students draw the part of the circle

The final designing and developing results of the learning trajectory in this study contributed in the form of several activities to understand the concept of circles for eighth-grade students. These activities explain the steps that must be passed by students using the IRME approach through the context of the Ferris wheel. The steps that must be taken by students are divided into four learning activities, namely assembling a Ferris wheel, drawing a Ferris wheel illustration, making a list of circle elements, and identifying the parts of the circle.

Finally, the results of the evaluation questions given to students showed that, overall, the average score of the students is 3.14 with an Ideal Maximum Score of 4 (good category). It means that students had understood the concepts related to the parts of circle. Therefore, the Ferris wheel has a useful context as a tool used to design a learning trajectory for students' understanding of the concept of the parts of circle. These results supported several previous research results that stated the learning activity related to daily activity could be the starting point in learning mathematics (Alberghi et al., 2013; Cobb et al., 2008; Indriani & Julie, 2017; Júnior et al., 2013; Laurens et al., 2017; Nurdiansyah & Prahmana, 2017; Rejeki & Putri, 2018; Stevens & Moore, 2016; Wijaya, 2008). Therefore, the learning trajectory using the Ferris wheel can be an alternative activity in learning the concept of a circle for eighth-grade students.

Conclusion

The Indonesian Realistic Mathematics Education (IRME) approach using the Ferris wheel context has an essential role in producing a learning trajectory. The learning trajectory can support students' understanding of the concept of the parts of the circle in four activities. Firstly, in the informal stage, they are introduced to a circle through a Ferris wheel in an amusement park. Secondly, students can draw an illustration of four passengers in the Ferris wheel. Thirdly, students are making a list of the parts of the circle. Lastly, students can identify the parts of the circle, determine the relationship between the length of the radius and the diameter, also determine the difference in diameter with a chord. Furthermore, the study's results can be used to implement a learning trajectory that has been designed more broadly. It can also be compared with the results of other activities that use different approaches to generalize the effectiveness of this learning trajectory to improve students' understanding of circles.

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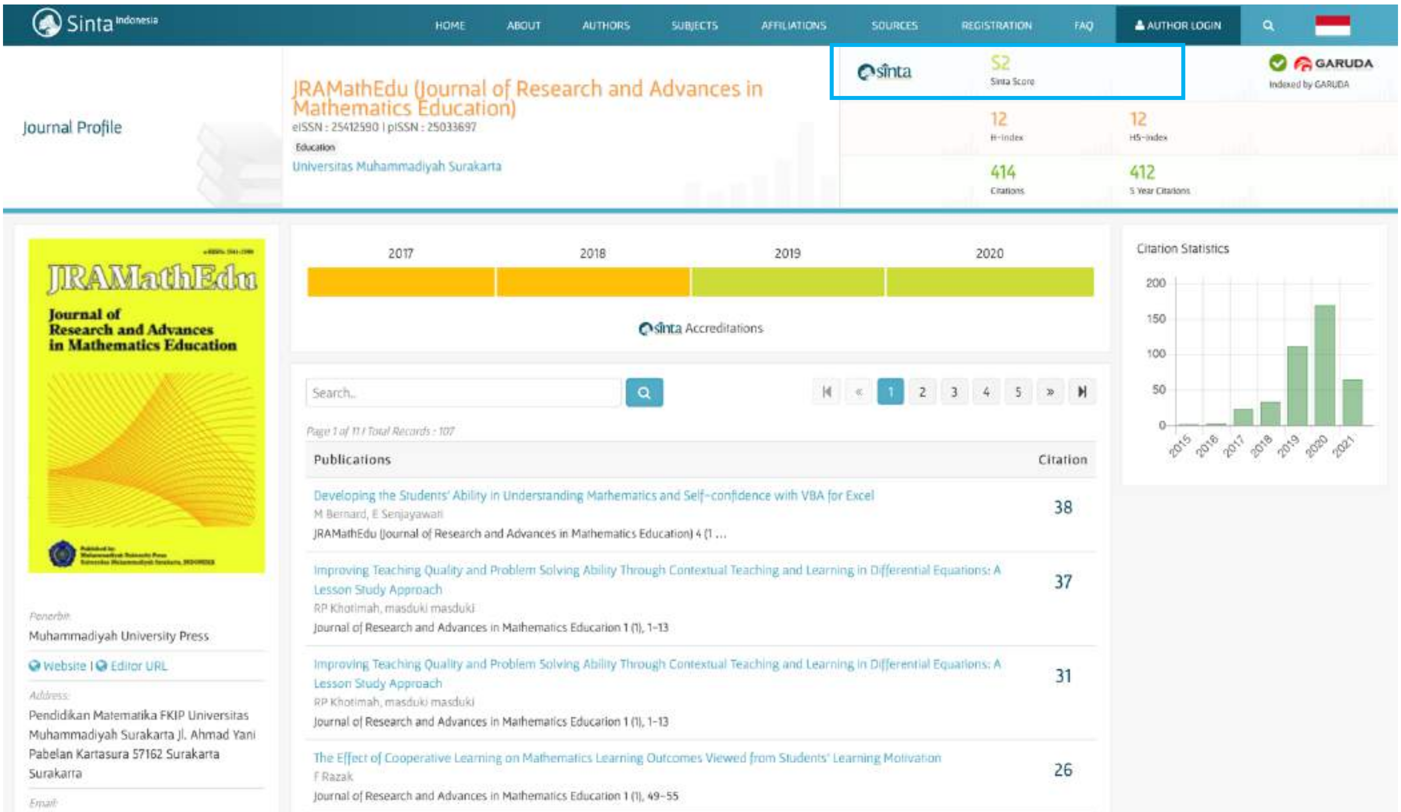

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