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Learning Reflection Using Realistic Mathematics Education Assisted by GeoGebra Software

Dwi Hardiyanto, Indhi Asokawati, Panji Maulana Majid, Atika Tri Maesaroh, Farida Nursyahidah*

Mathematics Education Department, PGRI University Semarang, Semarang, Indonesia
*Email: faridanursyahidah@upgris.ac.id

Abstract

Reflection material is very important for students to master when studying transformation material. However, reflection material is still difficult for students to understand. Therefore, this research aims to create a learning trajectory that can help students understand the concept of reflection using the context of the *Tedhak Siten* tradition with the help of GeoGebra software in grade 9th of SMP Negeri 6 Semarang. This research uses a design research method consisting of three stages: preliminary design, design experiment, and retrospective analysis. In this research, a series of learning activities were designed and developed based on the (Realistic Mathematics Education) RME approach. This research involved 6 grade 9th students. The result of this research is a learning trajectory that includes a series of learning processes in three activities, namely: 1) Observing the *Tedhak Siten* tradition video to find the definition and characteristics of reflection; 2) Finding formulas and reflection results; and 3) Resolving contextual problems related to reflection. The conducted activity can aid in improving students' comprehension of reflection material. The research results showed that students could discover the characteristics and definitions of reflection, find formulas and reflection results, and solve contextual problems related to reflection.

Keywords: Reflection, Realistic Mathematics Education, Design Research, *Tedhak Siten* Tradition

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INTRODUCTION

Transformation is essential for students, but at the same time, it is often difficult for them to understand (Fife et al., 2019). Transformation is very important to study in schools because this concept underlies other concepts, such as function and symmetry (Handayani & Sulisworo, 2021). The transformation consists of reflection, translation, rotation, and dilatation (Kemendikbud, 2022). This research only focuses on reflection because it covers much material, and reflection material will be the basic concept for other material, namely rotation and dilatation (Lestariningsih, 2017). Studying transformations is very important because it can hone students' mathematical skills and develop students' spatial competence, critical thinking abilities, and mathematical proof abilities (Maulani & Zanthy, 2020; Pertiwi & Siswono, 2021). However, transformation is still material that is difficult for students to understand (Lestariningsih, 2017; Surgandini et al., 2019).

Difficulties faced by students in transformation material include identifying the position of the image resulting from reflection, solving problems related to the displacement of the position of objects, identifying questions related to rotated lines, and identifying the position of the image of a point by dilatation (Maulani & Zanthy, 2020). Other difficulties are when students solve translation problems, describe the reflection of an object with the line y = x as a mirror, solve problems related to rotation, and the inability of students to solve problems related to dilation (Surgandini et al., 2019). This difficulty is influenced by several factors, including teacher-centered learning (Tasman et al., 2016) and the lack

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of learning media to provide clear visuals so students can absorb the material optimally (Maulani & Zanthy, 2020).

Through teacher-centered learning, students become passive, do not dare to express opinions, have low self-esteem, are not critical, and are not productive (Mujahida & Rus'an, 2019). Teacher-centered learning can hinder students' educational development because students are not given the freedom and responsibility to develop their knowledge (Dahlan, 2019). Apart from that, the lack of variety in learning media makes students less interested in learning (Dewi & Izzati, 2020), and learning becomes boring (Yusa & Sukmana, 2022). Learning with this method can result in low learning outcomes.

Low learning outcomes are caused by several factors, including teachers not connecting learning with real-life or students' daily lives, teachers using traditional teaching models that emphasize lectures and assignments, students participating passively in-class activities, the interaction between students and teachers rarely occurring (Ardiyani et al., 2018). Apart from that, the lack of use of learning media can lower student learning outcomes (Suryaman & Ni'mah, 2022).

A learning approach that can relate the material to students' real lives, increase student activity, and use appropriate learning media is needed to improve student learning outcomes. As an alternative solution to the difficulties of learning transformation material, learning planning is carried out using Realistic Mathematics Education (RME) by highlighting the usefulness of concepts (Mariyana et al., 2018). Learning through RME is often used to improve students' low interest, attitudes and skills (Fahrurozi et al., 2018; Nursyahidah et al., 2013, 2018). The RME approach has five main characteristics: context, models, constructivism, interactiveness, and interconnectedness (Fahrurozi et al., 2018).

Learning media that is suitable for learning transformations is GeoGebra software, which can provide a visual representation of mathematics from the context used (Afhami, 2022). The use of GeoGebra software in learning has been proven to be able to realize effective learning (Magfirah et al., 2021), increase motivation (Kusuma & Utami, 2017), increase student learning independence (Fasa et al., 2020), and increase students' understanding of concepts in geometry material (Jelatu et al., 2018).

One of the characteristics of RME is using context (Najwa, 2018). Some contexts for mathematics learning activities that can be used include traditional games (Nursyahidah et al., 2013), folk tales, legends, community customs (Nursyahidah et al., 2018, 2020; Nursyahidah & Albab, 2021), wayang stories (Arbowo et al., 2018), and historical buildings (Fahrurozi et al., 2018).

One context that can be used as a starting point for transformation material is the *Tedhak Siten* tradition. The *Tedhak Siten* tradition was used in this research because the components in the *Tedhak Siten* tradition can represent transformation material, such as the cane ladder, which represents reflection. *Tedhak Siten* comes from two words: tedhak, which means down, and siten, which means land. So, *Tedhak Siten* means going down to the ground (Rahayu et al., 2022). The *Tedhak Siten* tradition is carried out when a baby is seven months old to make the child honest, happy with the

knowledge, generous, and has a high work ethic (Syahira et al., 2022).

The novelty in this research is that the *Tedhak Siten* tradition is used to design geometric transformation learning, which has never been used before. With the RME approach and the help of GeoGebra software, this learning design can help students understand the concept of transformation. Previous research proved that reflective learning using the RME approach was proven to increase students' understanding of the concept of reflection (Nursyahidah et al., 2020; Tunnisa et al., 2018).

Based on the background described above, the author researched grade 9 transformational learning design using the context of the *Tedhak Siten* tradition. Learning will be designed in a Hypothetical Learning Trajectory (HLT) assisted by GeoGebra software.

METHODS

The method used in this research is design research. Design research is a series of approaches to produce new theories, artifacts, and practical models that explain and impact learning in natural settings (Akker et al., 2006). Design research consists of three stages: preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2006).

Preliminary Design

In this stage, the main focus is on developing a sequence of learning activities and designing learning activities and designing learning instruments, emphasizing reflection using the RME approach. A literature review is conducted to deeply understand the subject matter, including prerequisite materials that form the basis for students' conjectural thinking. Subsequently, an HLT is formulated as a guide for learning, where conjectures serve as flexible guides that can be revised throughout the experimental design phase.

Design Experiment

In this phase, the main activity involves testing the designed learning trajectory during the learning process. The goal is to explore and anticipate students' strategies and thinking. The experimental design consists of two stages: the pilot experiment and the teaching experiment. The research subjects include six ninth-grade students categorized as two with low ability, two with moderate ability, and two with high ability, based on teacher recommendations derived from previous learning outcomes. The study took place from August to September 2023. Data were collected through observation techniques, interviews, collection of student work, photography, and video recording. The accompanying lecturer and subject teacher standardized and validated all test instruments.

Restrospective Analysis

In this phase, the activity involves comparing the conjectures within the Hypothetical Learning

Trajectory (HLT) with the results from the design experiment stages. This retrospective analysis aims to provide a deep explanation of the learning trajectory in the context of rotational learning, applying the *Tedhak Siten* tradition. By comparing conjectures with experimental results, this research aims to identify how the designed HLT aligns with reality and its impact on students' conceptual understanding.

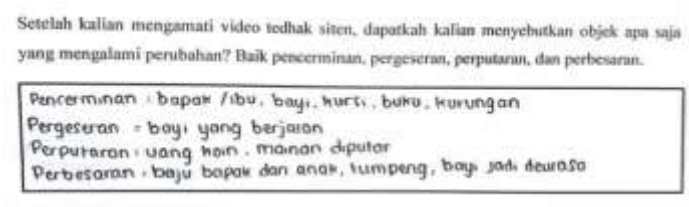
RESULTS AND DISCUSSION

The results of this research are a learning trajectory in the context of the *Tedhak Siten* tradition to understand reflection material in grade 9th. This learning trajectory includes three activities adapted to the characteristics of RME to make it easier for students to understand reflection material. The three activities in this learning pathway include: 1) observing the *Tedhak Siten* tradition video to discover the definition and characteristics of reflection, 2) finding the formula and reflection results, and 3) solving contextual problems related to reflection. Students' work in this learning trajectory can be understood and results from assignments and interviews, which have been standardized and validated by accompanying lecturers and subject teachers. The following is a detailed explanation of the results of this research:

Activity 1. Observing the Video Tedhak Siten Tradition to Find Out the Definition and Characteristics of Reflection

Figure 1. Video of the *Tedhak Siten* tradition

In activity 1, students are asked to explore the video context of the *Tedhak Siten* tradition displayed to understand the reflection material. Activity 1 begins by dividing students into three groups consisting of 2 students with high abilities, two with medium abilities, and two with low abilities. Next, the teacher gives students a worksheet containing instructions and a series of activities that students will carry out to understand the reflection material. After that, students are asked to find an object that experiences reflection in the *Tedhak Siten* tradition. Student answers can be seen in Figure 2.


Setelah kalian mengamati video tedhak siten, dapatkah kalian menyebutkan objek apa saja yang mengalami perubahan? Baik pencerminan, pergeseran, perputaran, dan perbesaran.

Pencerminan : bapak /ibu, bayi, kursi, buku, kurungan
Pergeseran : bayi yang berjalan
Perputaran : uang koin, mainan diputar
Perbesaran : baju bapak dan anak, lumpeng, bayi jadi dewasa

Translated to English:

Question: After observing the Tedhak Siten tradition video, can you find objects that experience reflection?

Student answers: baby, chair, book, cage

Figure 2. Students' answers regarding objects experiencing reflection

Based on Figure 2, students could find an object that experienced reflection, confirmed by the correct answers from the three groups. Next, students are asked to draw objects that experience reflection. Students' answers can be seen in Figure 3.

Translated to English:

Question: Draw an object that you think is experiencing reflection!

Student answer: Picture a chair with a mirror in the middle.

Figure 3. Image of an object experiencing reflection

The results of student interviews regarding objects experiencing reflection are as follows:

Researcher : *Why do you say the chair experiences reflection?*

Student : *Because I can determine the position of the mirror, Sir.*

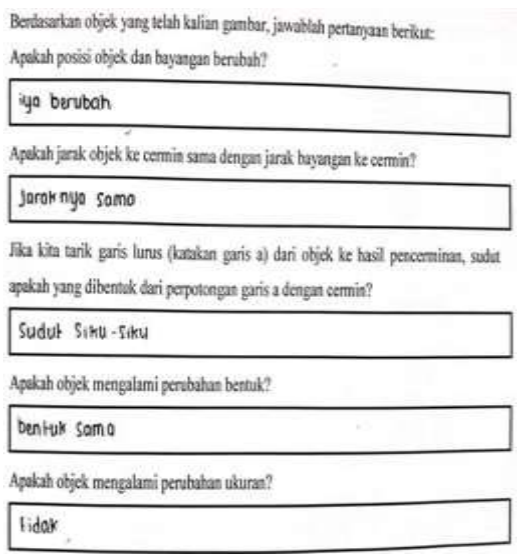
Researcher : *From the picture of the chair, where is the position of the mirror?*

Student : *In the middle sir (pointing to the black line in the middle). This is the object (pointing to the chair on the left) and this is the image (pointing to the chair on the right).*

Researcher : *If the object is this (pointing to the chair on the right) and the image is this (pointing to the chair on the left), is that OK?*

Student : *Yes sir, as long as the shape is the same, it doesn't matter if the object and image are reversed.*

Figure 3 and the interview results show that students can determine the location of a mirror on the object experiencing reflection along with the position of the object and its image. Next, students are asked to answer questions that lead to the characteristics of reflection. Students' answers regarding the properties of reflection can be seen in Figure 4.



Translated to English:

Question: Are the object position and image position different?

Student answer: Yes, it has changed.

Question: Are the distance from the object to the mirror and from the image to the mirror the same?

Student answer: The distance is the same, sir.

Question: If a straight line is drawn from the object to the image, then the line will intersect with the mirror. What angle is formed by the intersection?

Student answer: Right angle.

Question: Does the object change shape? before and after reflection?

Student answer: The shape is the same.

Question: Does the object change size? before and after reflection?

Student answer: Not changed

Figure 4. Student answers regarding the properties of reflection

The results of interviews with students regarding the nature of reflection can be seen below:

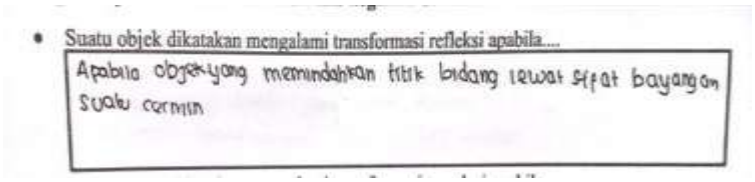
Researcher : *Why do you say the distance of the object to the mirror is the same as of the image to the mirror?*

Student : *Because the position of the mirror is in the middle, the distance from the object to the mirror is the same as from the image to the mirror.*

Researcher : *How did you get the answer, that the intersection of line a with the mirror forms a right angle?*

Student : *I look at the picture of the chair, there is a line that intersects with the mirror. The intersection will be perpendicular to the mirror, because it refers to the nature of the mirror. So a right angle will be obtained.*

The interview and Figure 4 results show that students can correctly determine the properties of reflection. Even though they were initially confused, they could answer the questions correctly after being given directions. Next, students are asked to define reflection in their own words. Students' answers regarding the definition of reflection can be seen in Figure 5.



Translated to English:

Question: An object is said to experience reflection if...

Student answer: Objects move through mirror properties

Figure 5. Student answers regarding the meaning of reflection

Based on Figure 5, students can define reflection in their language. So that the learning objectives in activity one can be fully achieved.

Activity 2. Find the Formula and Reflection Results

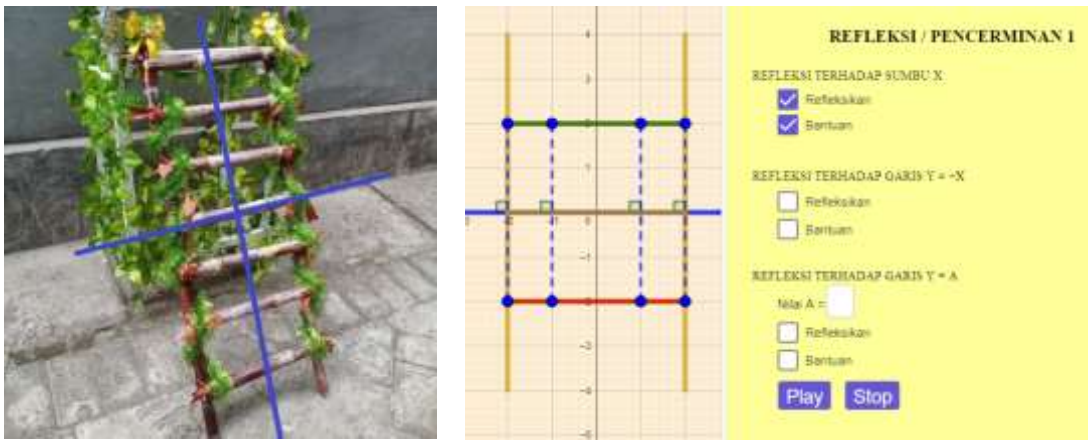


Figure 6. Sugarcane stairs and illustrations in geogebra

Activity 2 (Figure 6) begins with students observing one of the pieces of equipment in the *Tedhak Siten* tradition, which represents reflection, namely the sugar cane ladder. Then, the cane ladder is illustrated in GeoGebra software, which is designed to help students find reflection formulas. In the

GeoGebra illustration, several points on the cane ladder will be reflected later. By comparing the coordinates of the points before and after reflection, students are asked to find the reflection formula regarding the x-axis, y-axis, line y=x, line y=-x, line x=h, line y=h, and point (0,0). Students' answers regarding the reflection formula can be seen in Figure 7.

Mari kita amati bagaimana proses pencerminan terjadi dengan mengisi tabe berikut!

Titik Asal	Refleksi	Titik Bayangan
$A = (-2, 2)$	Terhadap garis $y = x$	$A' = (2, -2)$
$B = (-2, 1)$	Terhadap garis $y = x$	$B' = (1, -2)$
$C = (-2, -1)$	Terhadap garis $y = x$	$C' = (-1, -2)$
$D = (-2, -2)$	Terhadap garis $y = x$	$D' = (-2, -2)$
(x, y)	Terhadap garis $y = x$	(y, x)

Kesimpulan

Operasi pada refleksi jika titik asalnya adalah (x,y)

No.	Penerimaan Terhadap	Titik Koordinat Bayangan
1	Sumbu x	x,-y
2	Sumbu y	-x, y
3	Titik asal O (0,0)	-x,-y
4	Garis $y = x$	y, x
5	Garis $y = -x$	-y,-x
6	Garis $y = b$	x, 2b-y
7	Garis $x = a$	2a-x, y

Translated to English:
Reflection of the line $y = x$
Student answer: point (x,y) will become (y,x)

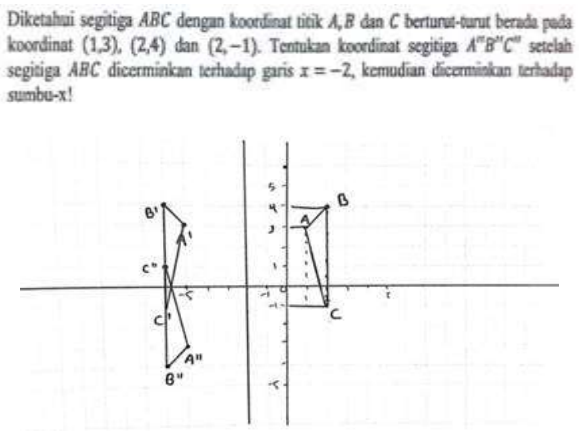
Translated to English:
Reflection (x,y) against x-axis, y-axis, line y=x, line y=-x, line x=h, line y=h, and point (0,0).

Figure 7. Student answers regarding the reflection formula

Researcher : *How do you find the reflection formula for the line $y = x$?*

Student : *I looked at the coordinates of the starting point (titik asal) and the shadow point (titik bayanagn), Sir, the starting point and the shadow point have the same pattern, namely the x value at the starting point changes to the y value at the shadow point, while the y value at the starting point changes to the x value at the shadow point. So it can be concluded that the value (x, y) at the starting point will change to the value (y, x) at the shadow point.*

Based on Figure 7 and the interview results, students can determine the reflection formula but still need help determining the reflection formula for the lines x=h and y=h. After being given directions, students could finally find the reflection formula for the lines x=h and y=h. Next, students are asked to find the reflection resulting from a point, line and plane. The questions given consist of single and repeated reflections. Students' answers regarding drawing shadows of points, lines and planes of reflection can be seen in Figure 8.



Translated to English:
Question: Reflection of the ABC plane with $A = (1,3)$, $B = (2,4)$ and $C = (2,-1)$ on the line $x = 2$, and the x-axis
Student answer: in the figure

Figure 8. Student answers regarding the reflection of an object

The results of student interviews regarding how to reflect on the field can be seen below:

Researcher : *How do you reflect the ABC plane?*

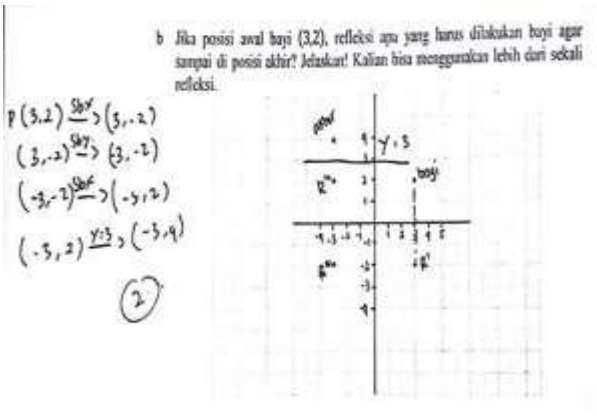
Student : *I reflect the points (A, B, and C) using the formula that has been obtained. Then I drew lines from the points after mirroring (A'', B'', and C'').*

Figure 8 and interview results show that students can determine the reflection results. Apart from that, students are also able to determine the image of an object resulting from multiple reflections. So, the learning objectives in Activity 2 are achieved.

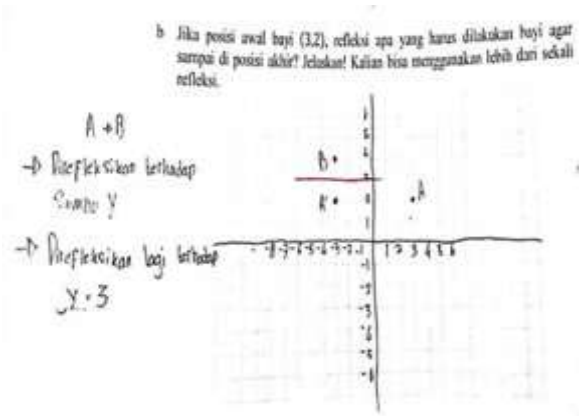
Activity 3. Solve Contextual Problems Related to Reflection

In activity 3, students are asked to solve reflection-related contextual problems. In this activity, students apply the knowledge they gained in the previous activity. Students are allowed to discuss with their group members. Students' answers in solving contextual problems can be seen in Figure 9.

In the tedhak siten tradition, there is a process where the baby is guided by his parents to pass through 7 jadah. If the baby's position is at coordinates $(3,2)$, while the position is at coordinates $(-3,4)$. What reflection should a baby do to get through the 7 jadah?



Student answer: Reflection on the x-axis, y-axis, x-axis, and y line=3



Student answer: Reflection on the y-axis and y line=3

Figure 9. Students' answers to contextual problems related to reflection

Figure 9 shows that students can solve contextual problems related to reflection. This can be seen from the wide variety of student answers. So, the learning objectives in activity three were achieved.

Based on activity 1, students can find objects that experience reflection, discover the properties of reflection, and define reflection using their language. Using the *Tedhak Siten* traditional context can help students understand the definition and characteristics of reflection. This is in line with (Surgandini et al., 2019), who said that context positively impacts the learning process, makes students more active, and makes students not think that mathematics is abstract. Also, (Nursyahidah et al., 2013, 2020; Risdiyanti & Prahmana, 2020) also said that an appropriate context can develop students' mathematical thinking and understanding.

In activity 2, students could find formulas and reflection results with the help of GeoGebra software. Using GeoGebra software has been proven to increase motivation and help students understand transformation material. This aligns with (Kusuma & Utami, 2017) who say that GeoGebra software can increase student learning motivation. Besides that (Jelatu et al., 2018) also said that GeoGebra software can help students understand geometry material.

Students were able to solve contextual problems related to reflection in activity 3. This was because the problems given were related to the two activities they had worked on previously. Apart from that, by applying the RME approach, students can understand the concept of reflection. This aligns with (Tunnisa et al., 2018), who say that the RME approach provides opportunities for students to understand and build the concept of reflection.

Apart from that, using RME assisted by GeoGebra software can help students understand reflection material. This happened because students were helped visualize GeoGebra software, and learning became more meaningful with the RME approach. This is in line with (Lestari et al., 2021; Surgandini et al., 2019), who say that the application of RME assisted by GeoGebra can grow and improve students' understanding of the concept of geometric transformation.

CONCLUSION

This research produces a learning trajectory for reflection material to make it easier for students to understand the concept, which consists of 3 activities, namely: 1) observing the video *Tedhak Siten* tradition to find out the definition and characteristics of reflection; 2) finding the formula and reflection results; 3) and solving contextual problems related to reflection. The results of this research show that a series of activities that have been designed can help students understand concepts in reflection material using the context of the *Tedhak Siten* tradition. Apart from that, the results of this research also add alternative local wisdom that can be used as a context for mathematics learning in reflection material.

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