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HYPOTHETICAL LEARNING TRAJECTORY DESIGN IN REFLECTION LEARNING USING THE CONTEXT OF THE CIREBON RED MOSQUE

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Abstract

This research aims to design a reflective learning trajectory using the context of the Cirebon Red Mosque as the starting point or learning context. The method used in this research is design research with stages of preliminary design, design experiment and retrospective analysis. The subjects in this research were several samples of class VIII junior high school students. The results of this research are a hypothetical learning trajectory design in reflective learning using the context of the Cirebon Red Mosque with a learning trajectory, namely students observing pictures from the front gate of the Red Mosque, having discussions and finding the meaning and properties of reflection, students drawing objects with agreed conditions, students record the starting point and ending point of the reflection results and find the relationship between the two and finally, students find the reflection formula. The research results show that a series of activities in the context of the Cirebon Red Mosque have a potential impact on understanding the concept of reflection. Students work on mathematics collaboratively and the learning process becomes meaningful and easy.

Keywords: hypothetical learning trajectory; design research; pmri; reflection; cirebon red mosque

1. Introduction

Mathematical problems in the form of projects and related to everyday life are still not able to be applied well by Indonesian students. This is proven several times by the results of the Trends in International Mathematics and Science Study (TIMSS) (Hidayat, et al. 2023). In TIMSS 2015, Indonesia was ranked 46th out of 51 countries with a score of 397 (Safari, 2021). Then, in the 2018 Program for International Student Assessment (PISA) results, Indonesia obtained a score of 379, which shows a decrease of 7 points from that obtained in 2015 (Setiawan et al., 2021).

Mathematics learning process in schools tends to apply practical formulas (Lailah & Hamidah, 2023) and does not yet connect mathematics with culture and daily activities (Risdiyanti & Prahmana, 2018). In fact, mathematics is a human activity and must be connected to everyday life (Andriani, 2020; Zaenuri & Dwiyanti, 2018; Isnaeni, et al, 2019). Apart from that, the application and development of mathematical concepts based on problems in everyday life is part of the student learning process (Siagin, 2016).

Nuraida and Amam (2019), stated that the difficulties faced in learning mathematics that were not yet connected to everyday life ultimately motivated Indonesian mathematics educators to find learning methods that were oriented towards technical skills towards reforming mathematics education based on solving problems in everyday life. -day. The learning method is Indonesian Realistic Mathematics Education (PMRI) (Domu & Mangelep, 2020) which is the result of an adaptation of Realistic Mathematics Education (RME) and has been aligned with the cultural, geographical and life conditions of Indonesian society in general (Zulkardi, et al, 2020).

Gravemeijer (Risdiyanti & Prahmana, 2018) stated that realistic mathematics education reform was implemented based on two things, namely the teacher's ability to create a class culture that is problem oriented as well as creating interactive learning and designing learning activities that can encourage the rediscovery of mathematics. In developing a learning design, it is necessary to formulate a hypothetical learning trajectory (HLT). Prahmana & Suwasti (2014) revealed that the development of HLT was formulated in three components, namely learning objectives, mathematical ideas used, and learning process hypotheses.

Cirebon, a city rich in cultural, historical and religious heritage, has many historical sites of great cultural and religious significance. Cirebon is the only city in West Java that has three palaces (Astari & Rochman, 2023). One of the prominent historical sites in Cirebon is the Red Mosque. This mosque is not only a place of worship, but also a symbol of local wisdom and Cirebon culture (Siswoyo & Mardiana, 2019). Apart from being a place full of historical and spiritual values, it also has unique architecture (Hamidah & Susilawati, 2023).

Therefore, one of the solutions offered to solve this problem is to carry out learning innovations. This research is oriented to the relationship of mathematics in students' daily lives and culture. The novelty in this research is the stages of reflective learning activities using the Cirebon Red Mosque as a starting point or learning context. The aim of this research is expected to be a mathematics learning innovation that makes it easier for students to understand the concept of collaborative reflection, a learning process that is meaningful, easy, and fun.

2. Method

This research uses a design research research method which aims to improve learning practices in the classroom through interactive analysis of predictions of what will happen in the classroom and its implementation (Gravemeijer, 1994b). Prahmana (2017) defines design research as a suitable method for developing solutions based on research that develops or validates a learning process theory and the like. Design research is also defined as a method that aims to develop Local Instructions Theory by collaborating between researchers and teachers to improve the quality of learning (Gravemeijer & Eerde, 2009). This research consists of experimental ideas and learning experiments with 3 implementation stages (Gravemeijer & Cobb, 2006). Prahmana (2017) explains the three stages include Preliminary Design; Design Experiment; and Retrospective Analysis.

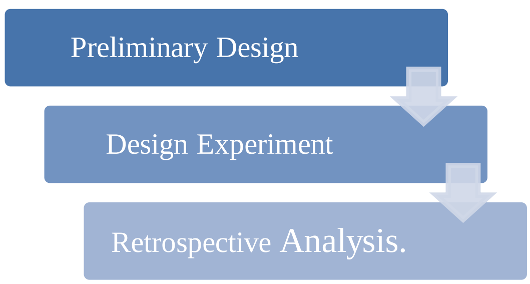


Figure 1. Research stages.

The preliminary design stage contains the initial steps in designing learning trajectory activities. Several things that are done in this stage include analyzing the KI and KD curriculum, indicators and learning objectives, reviewing literature regarding the concept of reflection in geometric transformation material, and PMRI, so that a conjecture or guess at student thinking can be formed. Apart from that, in this stage a Hypothetical Learning Trajectory (HLT) is created which is applied in learning to help students learn reflection material. In this stage, the conjecture functions as a guideline that emerges and develops in each learning activity and is flexible and can be revised during the design experiment stage.

Design experiment is the second stage in this research. At this stage, a process of testing learning trajectories that have been designed in the preliminary design is carried out. This stage aims to explore students' guesses, strategies and thoughts during the actual learning process. The stage carried out in this research was a teaching experiment stage which was tried out on several samples of research subjects.

Lastly, the Retrospective Analysis stage. At this stage, the conjectures in HLT are compared with the results from the design experiment stage. The results of this analysis can produce a description of the learning trajectory in reflective learning using the context of the Cirebon Red Mosque.

3. Results and Discussion

3.1 Results

The results obtained in this mini lesson research are an HLT design in which there is a learning trajectory in reflective learning using the context of the Cirebon Red Mosque as the starting point or context in learning. This research was tested on a limited basis on 9th grade junior high school students with varying abilities, totaling 6 people and divided into two groups randomly so that each group consisted of 3 people. The results obtained will be described in the following research stages.

3.1.1. Preliminary Design

At this stage the researcher carried out the process of designing reflective learning in class XI using the context of the Cirebon Red Mosque. Includes curriculum analysis, KI, KD, learning objectives, preparation of lesson plans, and creation of learning designs in the form of HLT which is the most important part of this research.

The preliminary design begins by determining the curriculum analysis, namely reflection material in the chapter on geometric transformations for grade 9 middle school. For more clarity, look at table 1.

Table 1. Curriculum Analysis

Basic competencies	Indicators of Competence Achievement
Explain geometric transformations (reflection, translation, rotation, and dilation) which are connected to contextual problems	Explain the definition of reflection
	Explain the properties of reflected images
	Determining the point of the reflected image.
	Find the formula for the reflected image

Learning objectives :

a. Through discussion and question and answer, students are able to explain the definition of reflection
b. Through discussion and question and answer, students are able to explain the properties of reflected images
c. Through discussion and question and answer, students are able to find the shadow point resulting from reflection
d. Through discussion and question and answer, students are able to solve problems related to reflection
e. Through discussions and questions and answers, students are able to analyze problems related to reflection

HLT is structured through a learning trajectory which contains a learning plan based on the reflection material that will be taught. In this case, the learning trajectory is a concept map that students will go through during the learning process. The learning trajectory used in this research is understanding the concept of reflection using the context of the red mosque. In the first activity, students are directed to observe the image and then guided through questions and activities so that students can name the characteristics of reflection. In the second and third activities, students are asked to describe objects and their shadows based on the instructions given. The next activity deepens the understanding of the relationship between the starting point and the ending point because of reflection. Finally, after achieving this understanding, you will find the reflection formula for the x-axis, y-axis, including the $x = y$ axis and the $x = -y$ axis.

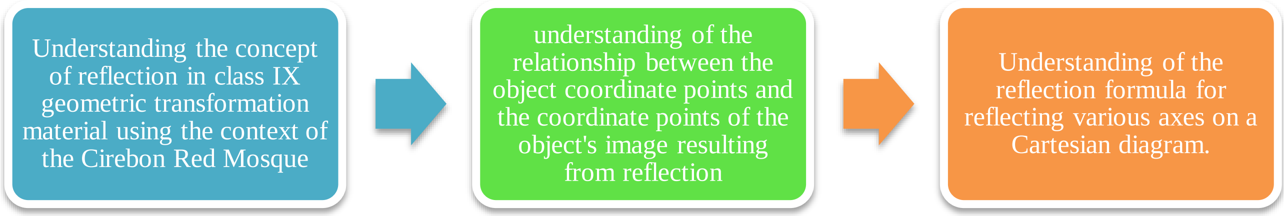


Figure 2. LT Reflection at Middle School Level

A collection of reflective learning activities based on learning trajectory (LT) and the results of student thinking are hypothesized in HLT (Hypothetical learning trajectory). Based on the HLT that has been prepared, a general student learning trajectory design is obtained in reflection learning at the junior high school level using the context of the Cirebon Red Mosque which is illustrated in the form of an iceberg.

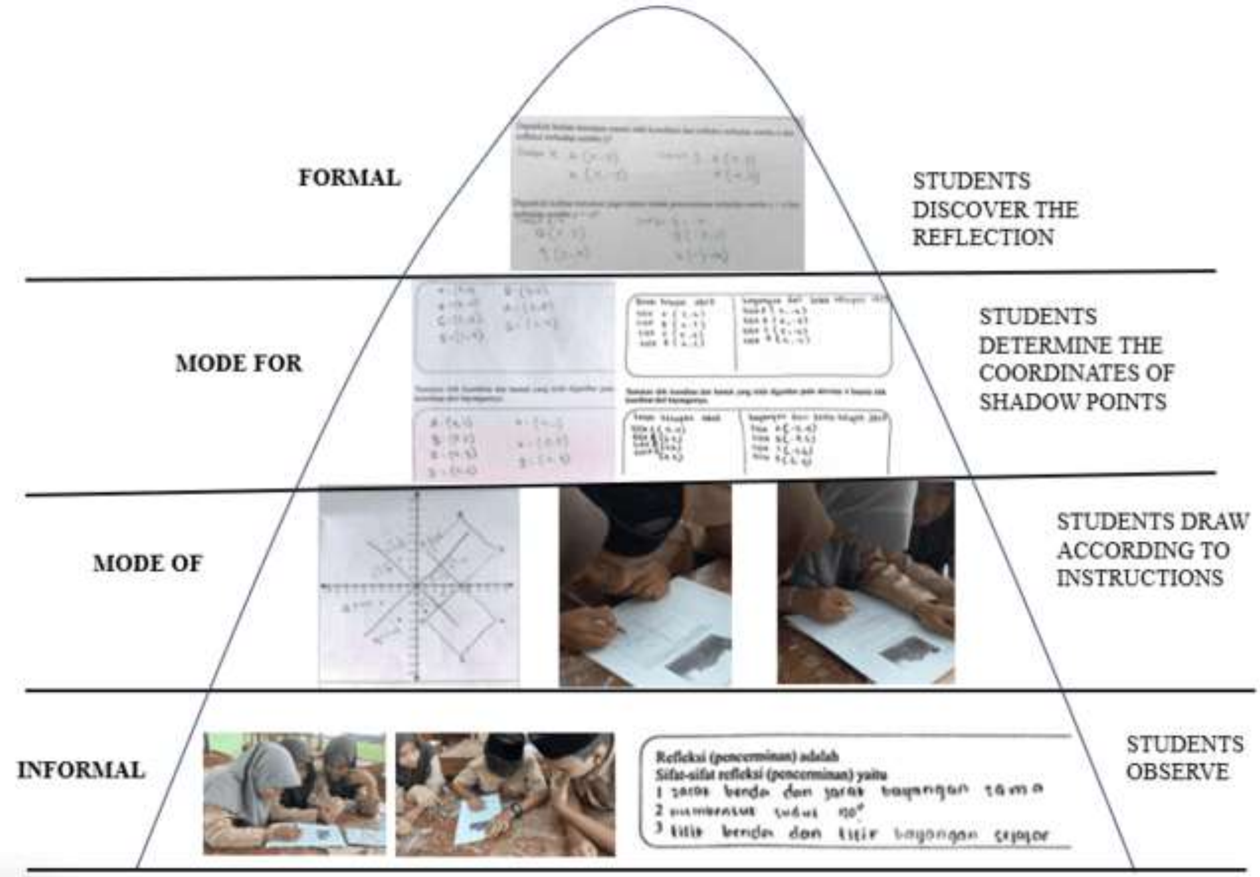


Figure 3. Iceberg HLT Reflective Learning at Middle School Level

Iceberg HLT in Figure 3 is the stages of student learning trajectory activities which are carried out from the informal stage to the formal stage. At the informal stage, students learn by observing the context, then enter the model of and model for, students continue to be guided and directed through the activities carried out until they reach the formal stage where students are able to find mathematical formulas from reflection. Based on the HLT that has been designed, a reflective learning conjecture can be obtained which can be seen in Table 2.

Table 2. Reflective Learning Conjecture at Middle School Level

Stage	Objective	Activity Description	Conjecture
In formal	Students can observe the image of the front gate of the Cirebon Red Mosque and find out its relationship to reflection material and be able to discover the properties of reflection	Students observe the image and analyze the relationship with the reflection material, and are able to describe the form of reflection with free objects to gain an understanding of reflection and its properties.	Students are not been able or able to observe images and their relationship to reflection material Students are able or unable to discover the meaning of reflection and its properties through observations and activities carried out
Model Of	Students can reflect a flat plane about the x-axis	Students describe a flat plane with certain conditions and reflect it on the x-axis	Students may or may not reflect on the x-axis
	Students can reflect a flat plane about the y-axis	Students describe a flat plane with certain conditions and reflect it on the y-axis	Students may or may not reflect on the y-axis
Model For	Students can determine the coordinates of the starting point and the coordinates of the end point of the reflection results in activities 2 and 3	Students record the starting and ending points of the reflection results in coordinate form	Students can or cannot record the starting point and ending point of the reflection results correctly
Formal	Students can find the mirroring formula	Students determine the relationship between the coordinate point of the object and the final coordinate point of the reflection and can write formulas for reflection on various axes	Students can or cannot find the relationship between the initial coordinate point and the final coordinate point resulting from the reflection and can determine the formula

All instruments that have been designed at the preliminary design stage, such as RPP, HLT and conjectures that have been created are then used as the basis for the experimental design stage. Apart from the instruments above, researchers also compiled interview and observation sheets to dig deeper into the responses or activities that students carried out

3.1.2. Design Experiment

At this stage the researcher conducted a learning trajectory experiment that had been designed for 6 class IX junior high school students and divided them into two teams. Then, the researchers conducted a retrospective analysis of the experimental results obtained in the design experiment stage. There are 5 activities carried out in the design experiment stage and are classified into several stages, namely activities in the informal stage, mode of, mode for and formal stage.

a. Informal Stage

At this stage, the activity carried out is observation, students observe the picture and then answer open questions related to the picture given. After that, students are also asked to describe free objects and then answer the next activity until students are able to discover the properties of reflection.

At this stage, students are familiar with the image in the LAS given, namely the gate of the Cirebon Red Mosque which is usually used as a place to commemorate the birthday of the Prophet Muhammad SAW and also other cultural customs activities, such as a place for storing keris and a place for the wali songo pilgrimage. This mosque is always busy, especially on Islamic holidays. So it is easy for students to analyze and observe the images. When answering questions on the activity sheet, students were able to answer them well. Slight obstacles arise when activities direct students to determine approximate distances, angles and parallel lines formed between objects and shadows. However, after the discussion process, students were able to discover the characteristics of reflection. The following activities can be seen in Figure 4.

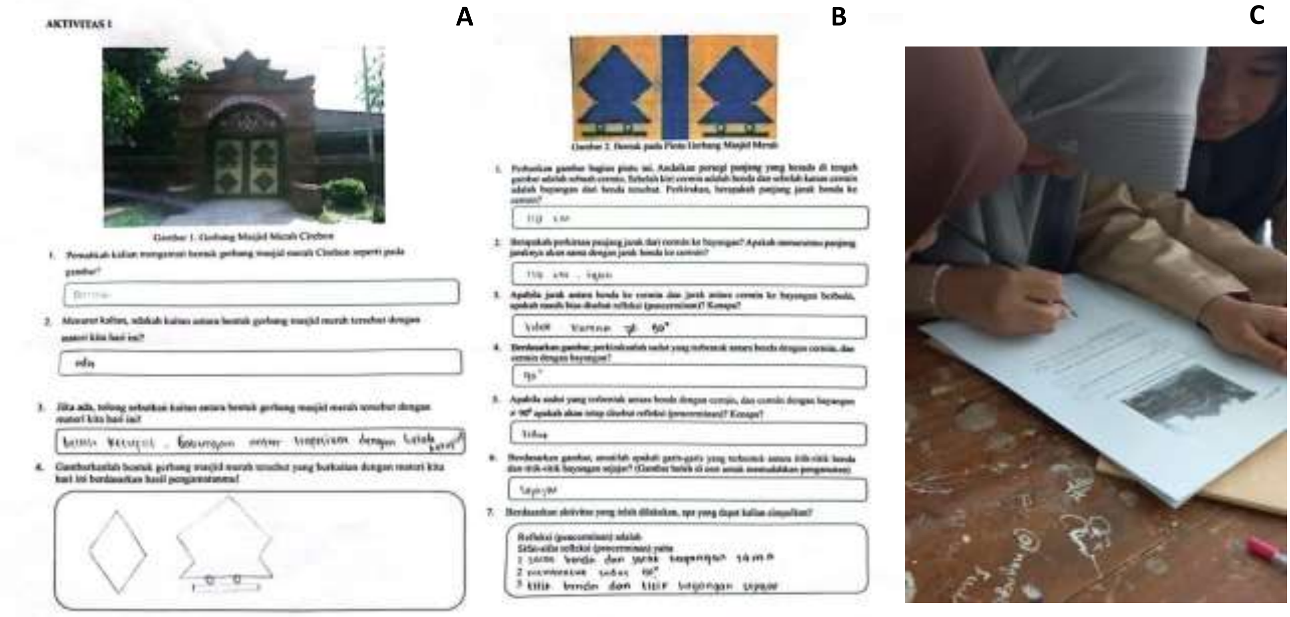


Figure 4. Informal Stage (A) Answers to activity 1 page 1, (B) Answers to activity 1 page 2, (C) Student collaboration in carrying out activities 1

b. Model Of Stage

The model of stage consists of two activities, namely the second activity and the third activity in the form of drawing one of the objects on the door of the Cirebon Red Mosque with an unspecified size. However, the teacher sets limits regarding the mirror and the location of the reflection. In the second activity, objects that students have drawn freely are then reflected on the x-axis. Meanwhile, in the third activity, the objects that students have drawn are reflected on the y-axis.

At this stage students learn how to reflect on the x-axis and y-axis semi-formally based on previously discovered reflection properties. At this stage, students begin to apply the properties of reflection a little in drawing shadows of objects so that the shape of the shadow matches the object and the mirror.

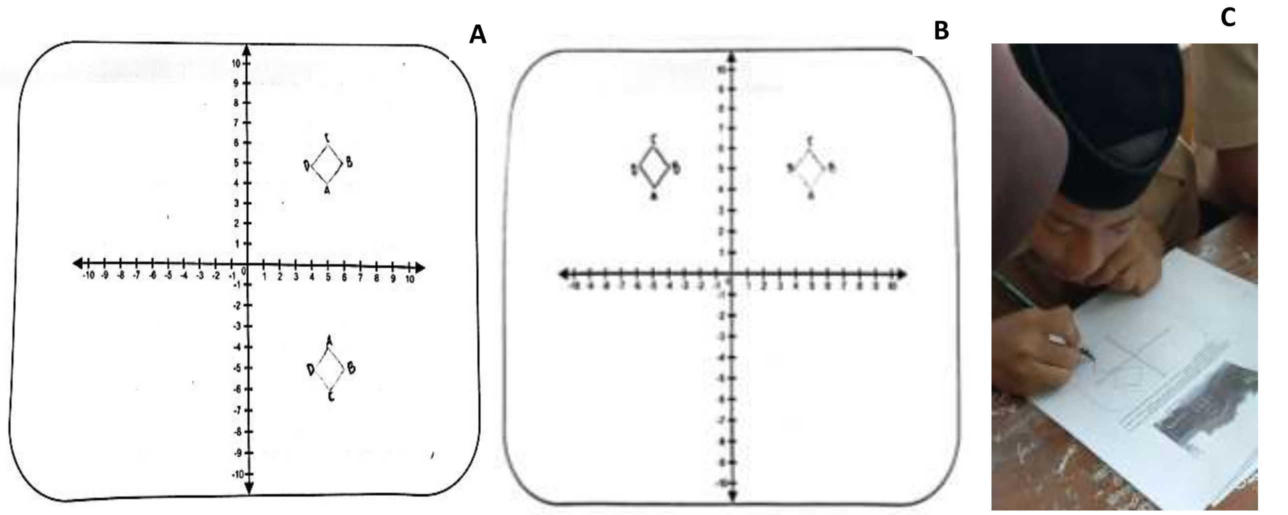


Figure 5. Model Of Stage (A) Answers to activity 2 page 1, (B) Answers to activity 2 page 2, (C) Student collaboration in carrying out activities 2

c. Model For stage

The activity carried out at the for mode stage is the fourth activity, students determine the coordinate points between the object and the image in activity two and activity three. Students record point by point according to the starting point of the object and the results of its reflection.

At this stage, students are directed to be able to determine the coordinates of the image created in the previous activity. In the process, some teams easily found the coordinates of the point, but others experienced difficulties. One of the research team asked how he answered. They answered, after discussing, they finally understood that the coordinates were obtained by projecting the x-axis and y-axis k points. The results of students' work in determining coordinates can be seen in **Figure 6.**

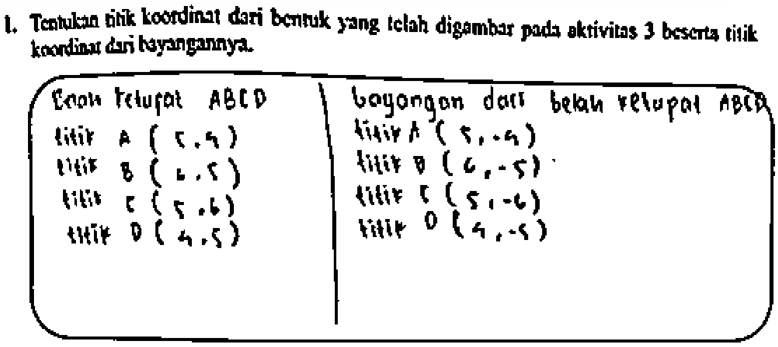
At this stage too, students begin to slowly enter the formal stage, starting from observing the drawings they have made in activities 2 and 3, finding the coordinates of the points of each image of objects and shadows based on the Chartesian diagram table. This is intended to make it easier for students to find the relationship between object points and image points, then the teacher and students discuss the relationship between the starting point and the ending point of the reflection results. Before students can enter the formal stage.

d. Formal stage

At the end of the activity, students begin to develop a formal form of reflection formula based on a series of activities they have gone through. Then, the teacher teaches students to try to use the activities they have gone through to reflect certain points on different axes, namely the y = x axis and the y = -x axis.

Students re-construct their understanding to make formulations of things that were not previously done in the activity, namely finding the formula for the y = x axis and the y = -x axis. Finally, students do the same activity as when they found the object point and image for the x-axis and y-axis until they are able to find the coordinate relationship of the object point and the multiplicity point for the y = x and y = -x axes. Next, students are guided by the teacher to conclude that the mathematical model found is a reflection formula on the x-axis, y-axis, y = x-axis, and y = -x-axis. The results of students' work in writing formulas can be seen in **Figure 7**

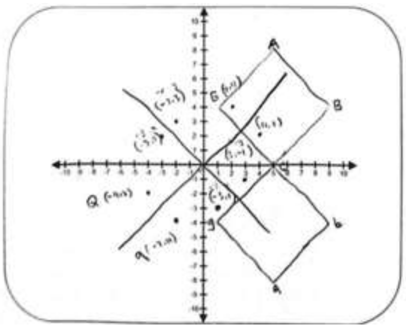
A



B

Figure 6. Model For stage (A) Answers to activity 3 page 1, (B) Student collaboration in carrying out activities 3

A



B

C

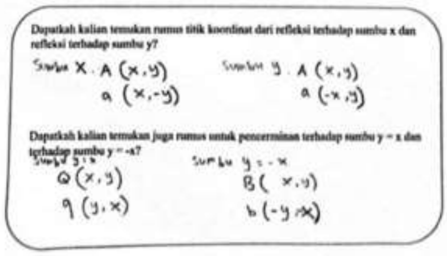


Figure 7. Formal stage (A) Answers to activity 4 page 1, (B) Student collaboration in carrying out activities 4, (C) Answers to activity 4 page 2

The teacher then helps students solve other problems that are often encountered in everyday life using concepts and reflection formulas that they already understand. At this stage, students have understood the concept and formula of reflection, as well as the properties of reflection. They have also been able to use reflection concepts and formulas to solve problems encountered in everyday life. Every reflective learning activity usually takes place interactively. Students are actively involved in discussions, provide answers, and explain why they chose certain answers.

3.1.3. Analysis Retrospective

Based on the results at the experimental design stage, it shows that the hypothetical learning trajectory (HLT) designed through student learning trajectory activities is effective and can facilitate students' understanding of reflection material. The learning track activity created allows students to study mathematics and at the same time get to know one of the red mosque tourist attractions which is the icon of the sacred mosque in Cirebon. Apart from that, learning uses a context that tends to be new compared to ordinary learning, making students more interested in the learning process.

3.2 Discussion

The results of this research show that in implementing geometric transformation learning, especially the reflection sub-chapter, you can use a learning design based on a local context that is close to students' lives, such as culture or other things that are easily found in students' daily activities. Based on the research results, it appears that students can understand mathematical concepts more easily, have fun, and reach their imagination so that mathematics can be accepted as a science whose benefits can be felt. This also makes it easier for students to solve problems encountered in everyday life.

This research is in line with the mathematics education reform that has been initiated by Indonesian mathematics researchers and educators through Indonesian Realistic Mathematics Education (PMRI) to create activity-oriented learning methods that involve students actively in learning. Each process is oriented towards solving problems and rediscovering mathematical concepts in everyday life to make students feel actively involved in discovering the mathematical concepts and formulas they are studying (Elisa & Zulkardi, 2020; Amarta, et al, 2023; Ambarwati, et al, 2023).

Several researchers have also created mathematics learning designs using the PMRI approach, such as geometry learning designs for critical thinking skills (Mulbasari, et al, 2023), PMRI learning designs in the fashion context for vocational school students (Asfyra, et al, 2023), fraction learning design in the context of a chessboard (Ramadhan, et al, 2022). Therefore, the role taken from the results of this research is to add to the study of mathematics learning design, namely reflective learning design in the context of the Cirebon Red Mosque. As for the limitations of this research, the research is still in the form of hypothetical learning trajectory (HLT). For future research, this research can be continued on more subjects and through a series of repeated paths with more than one application to produce Local Instructional Theory (LIT).

4. Conclusion

The results of this research show that a learning design in the form of a Hypothetical Learning Trajectory (HLT) which uses local context, such as culture, or other things that are easily found in students' daily activities, which in this research uses the context of the Cirebon Red Mosque, can be used for teaching geometric transformations, especially reflection material. This HLT design allows students to understand mathematical concepts easily, fun, and close to daily activities. This can also help students solve problems related to reflection material. For further research, we can design learning activities using context with material content that can be expanded, so that research is not only carried out on 1 reflection but can be carried out for all sub-chapters in the geometric transformation material.

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