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Learning Mathematics Using a Collaborative RME Approach in the Indoor and Outdoor Classrooms to Improve Students' Mathematical Connection Ability

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Abstract

Teaching approach applied by mathematics teacher can affect students' mathematical connection ability (MCA). The fact shows that there are still many teachers using conventional learning, causing passive students and low MCA among students. The purpose of this study was to describe the effectiveness of applying a collaborative realistic mathematics education (RME) approach using the classroom and the outdoor environment to improve students' MCA on the topic of similar triangles. This quasi-experimental research with a qualitative descriptive approach took the subject of ninth-grade students at a public junior high school in Jember, Indonesia. Data were collected using observation sheets, questionnaires, tests, and interviews. The data were analyzed using the effectiveness test (N-gain score). The results showed that the application of collaborative RME using the indoor and outdoor classrooms made students more active in physical, social, and mental activities. This learning is effective in improving students' MCA. The average score of 57.47 in the pre-test increased to 93.88 in the post-test, and the N-gain score was 0.86. Mathematics teachers are advised to apply this learning approach, not only on the topic of similarity triangles, but also on other suitable topics.

Keywords: Collaborative RME, Indoor and Outdoor Classroom, Mathematical Connection Ability (MCA), Student and Teacher Responses

Abstrak

Pendekatan mengajar guru matematika dapat mempengarui kemampuan koneksi matematis (MCA) siswa. Fakta menunjukkan masih banyak guru menggunakan pembelajaran konvensional, sehingga menyebabkan siswa pasif dan MCA siswa rendah. Tujuan penelitian ini adalah untuk mendeskripsikan efektivitas penerapan pendekatan pembelajaran matematika realistik (RME) kolaboratif menggunakan lingkungan dalam dan luar kelas untuk meningkatkan MCA siswa pada topik kesebangunan segitiga. Penelitian quasi experiment dengan pendekatan deskriptif kualitatif ini mengambil subjek siswa kelas IX di sebuah SMPN di Jember, Indonesia. Pengumpulan data menggunakan lembar observasi, angket, tes, dan wawancara. Data dianalisis menggunakan uji efektivitas (N-gain score). Hasil penelitian menunjukkan bahwa penerapan pembelajaran RME kolaboratif di dalam dan luar kelas menjadikan siswa lebih aktif, baik aktivitas fisik, sosial, dan mental. Pembelajaran ini efektif dalam meningkatkan MCA siswa, di mana rata-rata nilai pre test 57,47 meningkat menjadi 93,88 pada nilai post test, dan nilai N-gain score 0,86. Para guru matematika disarankan menerapkan pembelajaran ini, bukan hanya pada topik kesebangunan segitiga, tetapi juga pada topik lain yang cocok.

Kata Kunci: RME Kolaboratif, Lingkungan dalam dan Luar Kelas, Kemampuan Koneksi Matematis (MCA), Respon Siswa dan Guru

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INTRODUCTION

Mathematical Connection Ability (MCA) is the ability to relate mathematical ideas in solving problems in mathematics itself and problems in fields out of mathematics including daily life problems

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(Eli, Schroeder & Lee, 2013; NCTM, 2014; Pambudi, Budayasa, & Lukito, 2020). Mathematical connections play an important role in making students aware that mathematics is a science that is integrated into a single unit and not a collection of separate materials (NCTM, 2014; Sawyer, 2008). In addition, MCA helps students deepen their understanding of mathematics (García & Flores, 2018), as well as helps students achieve success in solving mathematical problems (NCTM, 2014; Pambudi, 2020).

MCA is so important that it is included in the objectives of learning mathematics in schools so that students are able to understand math concepts, explain connections between concepts, and apply it flexibly, accurately, efficiently, and appropriately in activity solve problem mathematics (MoEC, 2013). However, the facts show that MCA of students in Indonesia is still very low. Sugiman (2008) reported that MCA of new middle school students reached an average of 53.8 %, which still belonged to 'low' category. Saminanto & Kartono (2015) reported that MCA of students in solving daily-life problems only reached average score of 2%. Siregar & Surya (2017) also reported that MCA of middle school students in linking ideas in mathematics only reached an average score of 51.11% and their ability to link mathematics with daily-life problem reached an average score of 17.78%.

The low mathematics achievement of students, including students' MCA, can be caused by various factors, one of which is the conventional or mechanistic approach of teaching mathematics (Zulkardi, & Putri, 2019; Fauziah, Putri, Zulkardi, & Somakim, 2020; Pambudi, 2022). With the conventional approach, students are only asked to listen and do the practice questions individually so that the degree of student learning activity is low. Students are only given various abstract concepts by not giving them the opportunity to actively find and apply these concepts collaboratively to solve mathematical problems. In addition, the implementation of learning is only conducted in the classroom (Pambudi, 2022). This teaching approach needs to be replaced with other, more innovative ways. Here, an alternative, namely learning mathematics using Realistic Mathematics Education (RME) combined with collaborative learning and using an outdoor learning environment (Sunardi & Sugiarti, 2018; Pambudi, 2022), is proposed. Through the RME approach and collaborative learning in indoor and outdoor classrooms, it is hoped that students can be more actively involved in concept discovery and apply them to solve daily problems in the classroom and in the outdoor environment.

RME is a mathematics learning approach invented by Freudenthal in the Netherlands in 1968 (Van den Heuvel-Panhuizen & Drijvers, 2014). RME is widely applied and developed in various countries, such as in the USA where it is named Mathematics in Context (MiC) and in Indonesia where it is named *Pendidikan Matematika Realistik Indonesia* (PMRI) (Bustang, Zulkardi, Darmawijoyo, Dolk, & Van Erde, 2013; Zulkardi & Putri, 2019). The application of RME in Indonesia takes the context of the Indonesian environment and culture with five characteristics, namely (1) using the real world context as the beginning of learning; (2) using the model as a bridge between the real world and the abstract; (3) using student strategies, (4) involving student interaction and collaboration; and (5) paying attention to the relationship between concepts in learning (Zulkardi & Putri, 2020).

Several research results reported that the use of RME can increase students' MCA. Febriyanti, Bagaskorowati, & Makmuri (2019) investigated the use of RME in third-grade students in elementary school; Menanti, Sinaga, & Hasratuddin (2018); Hasbi, Lukito, & Sulaiman (2019) studied eighth-grade students in junior high school; and Elpina, Syarifuddin, & Yerizon (2020) researched ninth- grade students in junior high school. In additiom, Said, Pambudi, Hobri, Safik, & Insani (2021) are reported that RME was able to increase learning activities and students' communication.

Collaborative learning is a method in the learning process that involves student study groups to work together to complete tasks given by the teacher, such as discussion activities to solve math problems, complete projects, explore, and produce certain products (Inawati, Hobri, Pambudi, Guswanto, & Sya'roni, 2020). Collaborative learning is used based on the idea that learning is a social activity where each group member discusses among them to work together in completing the tasks given by the teacher. The use of collaborative learning has been shown to have a positive impact on improving students' communication and social skills, students' attitudes towards mathematics (Hossain, Tarmizi, & Ayub, 2012), and students' mathematics learning outcomes (Laal, & Ghodsi, 2012).

Furthermore, Outdoor Learning in Mathematics is a learning method that guides students to learn by utilizing the environment outside the classroom to guide students in learning mathematics to solve problems found outside the classroom. This method is widely applied in various countries, such as in England (Waite, 2011; Bilton, 2014), Finland (Bearnes & Ross, 2010), Sweden (Fagerstam & Blom, 2012), Scotland (Smarter Scotland Scottish Government, 2010), the Netherlands, USA, and Australia (Thomas, 2018), and succeeded in increasing student motivation and learning outcomes (Fagerstam & Blom, 2012; Pambudi, 2022), and improving students' MCA (Haji, Abdullah, Maizora, & Yumiati, 2017). Unfortunately, this method is still rarely used by mathematics teachers in Indonesia (Sunardi, Sugiarti, & Pambudi, 2018; Pambudi, 2022).

Similarity of triangles is one of the topics in mathematics studied by ninth-grade students in junior high school. On this topic, there are several interrelated concepts, namely the concepts of sides, angles, triangles, and comparisons that are linked in their entirety to produce the concept of similarity of triangles (MoEC, 2013). Here, students are required to develop MCA so that students succeed in finding the concept of similar triangles and then apply the concept to solve problems related to everyday life.

Generally, the topic of similar triangles is taught by the teacher using the lecture method, the teacher gives individual assignments, and learning is only conducted in the classroom. This causes passive students and low learning outcomes. Therefore, here, another alternative to teach the topic, namely collaborative realistic approach using the classroom and the outdoor environment, is proposed. This study is important to do to provide input to mathematics teachers in junior high school on how to teach the topic of similar triangles in an interesting way and be able to increase students' activeness and students' MCA.

The problems posed in this study are: "(1) How are the activities of junior high school students in finding the concept of triangle similarity?; (2) How are the activities of junior high school students in applying the concept of similarity triangles outdoor the classroom?”; (3) How is the flow of collaborative realistic mathematics learning in indoor and outdoor classrooms that occurs on the topic of similar triangles?; (4) How is the effectiveness of the application of collaborative realistic mathematics learning in indoor and outdoor classrooms in improving students’ MCA and learning outcomes?; (5) How is the response of students and teachers to the application of collaborative realistic mathematics learning in indoor and outdoor classrooms on the topic of similar triangles?”.

In connection with this problem, the purposes of this study are to “(1) describe the activities of junior high school students in finding the concept of triangle similarity; (2) describe the activities of junior high school students in applying the concept of similarity triangles in outdoor classroom”; (3) describe the flow of collaborative realistic mathematics learning in indoor and outdoor classrooms that occurs on the topic of similarity triangles; (4) describe the effectiveness of the application of collaborative realistic mathematics learning in indoor and outdoor classrooms in improving students’ MCA and learning outcomes; and (5) describe the responses of students and teachers to the application of collaborative realistic mathematics learning in indoor and outdoor classrooms on the topic of similar triangles.

The urgency of this study is to provide recommendation to junior high school mathematics teachers to apply collaborative realistic learning in indoor and outdoor classrooms as an alternative approach to increase students' activities and students’ MCA, especially on the topic of similar triangles.

METHODS

Research design

This study is a quasi - experimental research, using a pre-experimental design with one group pretest-posttest design (Table 1) combined with one-shot case study design (Table 2) (Arikunto, 2013; Creswell, 2014; Sugiyono, 2015). The approach used in this study was descriptive qualitative approach, which describes more qualitatively the results of the study.

Table 1. Design of group pretest- posttest

Pretest	Treatment	Posttest
O1	X	O2

Notes:
O1 = Pre-test
X = Giving treatment of collaborative learning with RME approach in indoor and outdoor classrooms
O2 = Post-test

Table 2. One-shot case study design

Treatment	Observation and Interview
X	O

Notes:
X = Giving treatment using collaborative learning with RME approach in indoor and outdoor classrooms
O = Observation and interview

From Table 1 and Table 2, we can describe that all students were taught mathematics using collaborative RME in indoor and outdoor classrooms on the topic of similar triangles. Before and after learning, all students were provided with pre-test and post-test. The activities of all students during the learning process were also observed. After finishing the lesson, group representatives were interviewed to discover their response to the lesson that had been implemented.

Research Subject

The research subjects were 5 male students and 12 female students of ninth-grade, class C (9-C) of a public junior high school (SMPN) in Jember, East Java, Indonesia, with an average age of 15 years. Ninth grade, class C was chosen using the purposive method. It was the class with the least number of students from the eight existing classes in ninth grade so that it would be easier for the teachers to manage the class and observe student learning activities. All students were taught mathematics using collaborative RME in indoor and outdoor classrooms on the topic of similarity triangles.

Method of Data Collection

The research data consists of (1) the process of student activities in finding the concept of triangle similarity; (2) the process of student activity in applying the concept of similar triangles to solve the problem of flagpole height in outdoor classroom; (3) realistic mathematics learning flow in indoor and outdoor classrooms; (4) student's MCA test before and after participating in learning; and (5) student and teacher responses to the application of collaborative realistic mathematics learning in indoor and outdoor classrooms on the topic of similarity triangles.

The data collection methods used were observation, questionnaire, test, and interview. Observations were conducted directly by recording the process of student activities when they found and applied the concept of triangle similarity. Short questionnaires were distributed to all students and teachers to discover the response to the application of realistic mathematics learning. Interviews were conducted with the teacher and three students representing three student study groups to discover how they responded to the application of collaborative realistic mathematics learning in indoor and outdoor classrooms. The student MCA test on the topic of triangle similarity was conducted by giving written tests (pre-test and post-test) to students. The test consisted of 4 descriptive questions, of which 2 questions are short essay questions and other 2 questions are problem solving questions, that students had to do in 60 minutes. The MCA indicators that were expected to appear from the completion of the test were (1) the ability of students to recognize mathematical ideas from contextual problems, (2) the ability of students to relate these ideas to construct new concepts, and (3) the ability of students to use these new concepts to solve daily-life problems. The test has been validated by 3 validators with a value of Va=4.30 (Valid).

Method of Data Analysis

The results of observations, questionnaires, and interviews were analyzed descriptively and qualitatively, i.e., by describing in words and presenting written data on how the students in the activity process found and applied the concept of triangle similarity to solve the problem of flagpole height outside the classroom and how students and teachers responded to application of RME. Students' MCA test results were analyzed using an effectiveness test (N-gain score) on pre-test and post-test data (Hake, 1999; Sundayana, 2015), with the formula as follows:

$$N\text{-}gain = \frac{posttest\ value - pretest\ value}{ideal\ value - pretest\ value}$$

The categories gain score can be seen in Table 3.

Table 3. Criteria for gain score (g)

N-Gain Score (g)	Category
$-1.00 < g < 0.00$	Occur drop
$g = 0.00$	Permanent
$0.00 < g < 0.30$	Low
$0.30 < g < 0.70$	Moderate
$0.70 < g < 1.00$	High

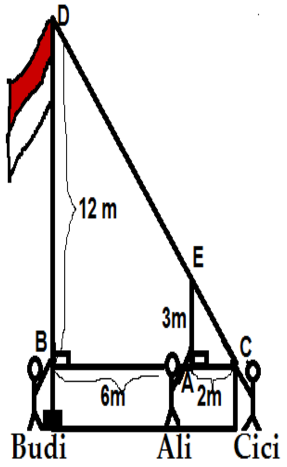
(Sundayana, 2015)

Table 3 shows the categories of learning effectiveness based on the N-gain score. Learning is said to be ineffective if the N-Gain score is between -1 to 0. Learning is considered more effective if the N-Gain score increases, from less effective (low), quite effective (moderate), to very effective (High) at intervals N- Gain score between 0.7 to 1.0.

RESULTS AND DISCUSSION

Description of Student Activity in Finding the Concept of Triangular Similarity

Student activities at the first meeting of learning using RME and Outdoor Learning Mathematics (OLM) on the topic of similar triangles can be described as follows. First, students prepared to participate in learning by listening to the teacher's instructions, receiving Students Workbook 1 (SW 1) which contains Contextual Problems (CP), as shown in Figure 1.



While playing around the flagpole, Ali, Budi, and Cici wanted to measure the height of the flagpole.

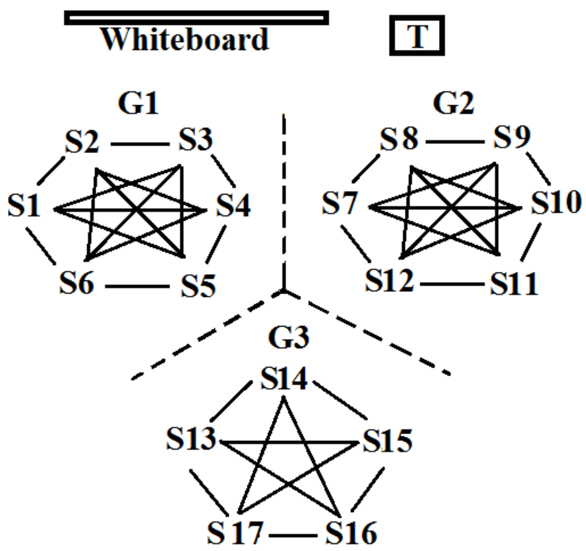
(a) From the picture on the side, look for two similar triangles, i.e., two triangles that have the same shape but different sizes. Then, determine what conditions must be met by the two similar triangles.

(b) If the lengths of the sides of the flat shape shown in the figure on the side are unknown, find the general formula for finding the height of the flagpole.

Figure 1. Contextual problem (CP) in SW 1

Figure 1 shows a contextual problem presented to students in SW1(a) and SW1(b), namely finding the triangle similarity formula from the activity of several students measuring the height of the flagpole in the school yard.

To solve the problem in SW 1, the teacher divided the students into three groups, each consisting of 5-6 students. All groups were given time to discuss the concept of similarity of triangles in SW 1 (a) and SW 1 (b). All groups did collaborative learning well, according to the class setting shown in Figure 2.



Notes:

Class Collaborative Settings:

T : Teacher

G1, G2, G3: Group 1, Group 2, and Group 3

S1, S2,..., S6 : Member G1

S7, S8,..., S12 : Member G2

S13, S14,..., S17 : Member G3

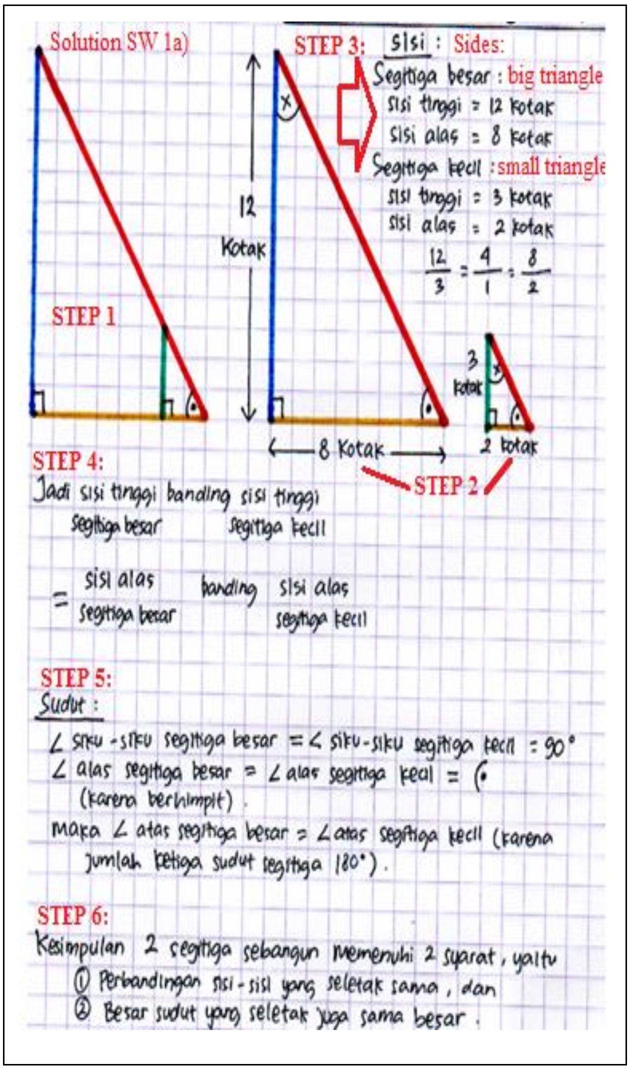
———: Students' interactivity

------- : Control path of Teacher

Figure 2. Class setting of collaborative learning

Figure 2 shows that the teacher set the class into 3 groups, namely group 1 (G1), group 2 (G2), and group 3 (G3). Each group member (5 to 6 students) sat close together to learn to collaborate in class. The full line connecting each group member shows that there was an active interaction of each member to work together to solve the problems in SW 1(a) and SW 1(b). The dotted line shows the teacher's path in monitoring group discussion activities. The teacher could provide motivation and instructions to all study groups if it was needed so that all groups got attention during the discussion.

An example of the results of group discussions in answering the problem of SW 1(a) can be seen in Figure 3.



Translated into English:

Answers to Student Workbook (SW) 1 (a):
STEP 1: Using graph paper, students draw large and small triangles with colored markers.

STEP 2: Students draw a large triangle and a small triangle separately according to their size.

STEP 3: Students observe the lengths of the two sides of the triangle and make a comparison between the height side 12 versus 3 units, and the base side is obtained 12:3 = 8:2 = 4:1.

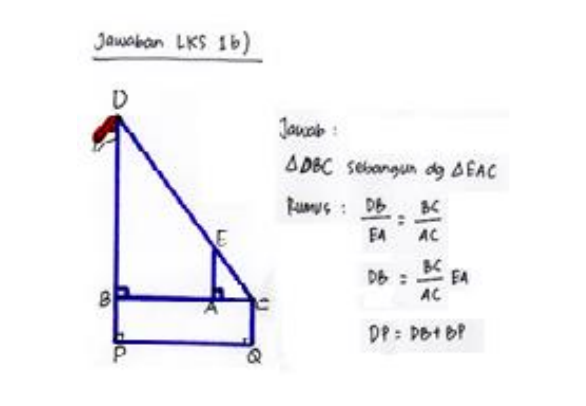
STEP 4: Students write down the first condition that must be fulfilled by 2 similar triangles, namely the ratio of the sides is the same.

STEP 5: Students observe the three angles in the 2 similar triangles. If the two base angles of the two triangles, one of which is a right angle, are congruent, then the other angles of the two triangles must be congruent as well.

STEP 6: Students write the conclusion that 2 triangles are similar if they fulfill 2 conditions, namely: (1) They have the same ratio of corresponding sides, and (2) The corresponding angles between them are equal.

Figure 3. Example of answers of group 1 to SW 1(a)

According to Figure 3, students collaborated in groups to rediscover the concept of similarity of triangles, using graph paper and colored markers. First, students drew a large right triangle which contained a smaller right triangle, then students separated the large right triangle and the small right triangle so that two similar triangles were seen. Next, by comparing the corresponding sides and angles of the two triangles, students obtained two conditions that must be met by 2 similar triangles. From this, students have done mathematical connection activities, namely recognizing mathematical concepts related to the problems given by the teacher, then linking the knowledge that students already have, which is the concept of a right triangle and the concept of comparison and linking the two concepts to obtain a new concept, which is the concept of similar triangles. An example of the results of group 1 work in SW 1(b) can be seen in Figure 4.



Translated into English:

Answers to Student Workbook (SW) 1 (b):

Answer:

ΔDBC similar to ΔEAC

Formula: $\frac{\mathrm{DB}}{\mathrm{EA}} = \frac{\mathrm{BC}}{\mathrm{AC}}$, $\mathrm{DB} = \frac{\mathrm{BC}}{\mathrm{AC}}\mathrm{EA}$

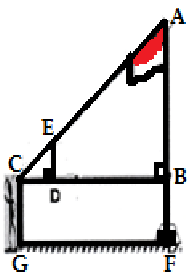
$\mathrm{DP} = \mathrm{DB} + \mathrm{BP}$

Figure 4. Example of answers of group 1 to SW 1(b)

Based on Figure 4, students managed to find the formula to find the height of the flagpole. Students drew flagpoles and triangles and rectangles according to the information from the problem, but omitted the lengths of the sides. Using the answers in SW 1 (a), students was able to find that ΔDBC is similar to ΔEAC, and write down the ratio of adjacent sides, so that the formula was obtained $\frac{DB}{EA} = \frac{BC}{AC}$. From this, $DB = \frac{BC}{AC}(EA)$ was obtained and the height of the flagpole is $DP = DB + BP$.

Description of Students Activities Applying the Concept of Triangle Similarity

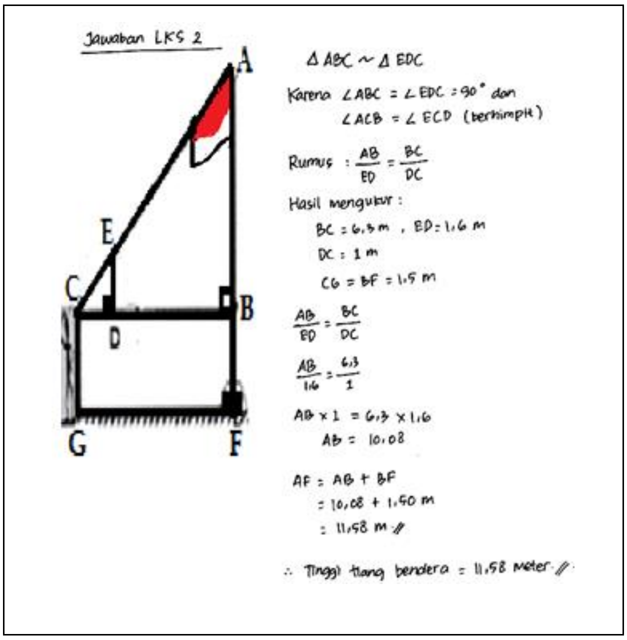
Students activities applying the concept of similarity of triangles took place at the second meeting. Here, the teacher invited all students to outdoor classroom, to the flagpole in the school yard, to be exact. The teacher explained the Contextual Problem (CP) in SW 2 and explained the task of each group to measure the height of the flagpole and discuss to make a report. The teacher divided the learning media, which consisted of a measuring tape, raffia rope, right triangle ruler, wooden stick, and Clinometer. CP in SW2 can be seen in Figure 5.



In groups, please measure the height of the flagpole in the school yard. You can use the image on the side or make your own. In the figure, AC and BC are flagpole hoist ropes, and DE are wooden sticks. Make sure that angles B and D are right angles. Use a measuring tape to measure the lengths of BC, CD, DE, and CG. When the measurment is finished, please fill out SW 2 and prepare presentations in class.

Figure 5. Contextual problem in SW 2

Figure 5 shows a problem that must be solved by students in groups outside the classroom. The problem is conducting an experiment to measure the height of the flagpole. In the school yard, all groups conducted various activities to apply the concept of similarity of triangles in finding the height of the flagpole. The activities of each member in the study group varied. There were students who hoisted the flagpole rope, there were students who held wooden sticks, there were students who checked right angles, there were students who measured the lengths of BC, CD, DE, and CG (according to Figure 5) using a measuring tape, and there were students who recorded the measurement results. The teacher observed student activities and provided instruction if it was needed. After completing the experiment, the students had discussion to answer the problem and fill in SW 2. In turn, all groups experimented with measuring the height of the flagpole by applying the concept of similar triangles. After everything was finished, the teacher asked all students to enter the classroom. In the classroom, group representatives presented the results of their group work to be discussed with other groups and the teacher. One of the results of Group 1's work can be seen in Figure 6.



Translated into English:

Solution to SW 2:

ΔABC ~ΔEDC, cause ∠ ABC=∠EDC=90 º

∠ACB =∠ECD (squeezed)

Formulas: $\frac{AB}{ED} = \frac{BC}{DC}$

Measurement results:

BC = 6.3m, ED = 1.6m,

DC = 1m

CG = BF = 1.5m

$\frac{AB}{ED} = \frac{BC}{DC}$

$\frac{AB}{1.6} = \frac{6.3}{1}$

$AB = 6.3 \times 1.6 = 10.08$

AF = AB+BF = 10.08+1.50 = 11.58 m.

Thus, the height of flagpole is 11.58 meters.

Figure 6. Results of group 1's work in measuring flagpole height

Based on Figure 6, it can be seen that the students succeeded in writing the formal form of the triangle similarity formula, i.e., triangle ABC is similar to triangle EDC (written in a formal mathematical symbol: $\Delta ABC \sim \Delta EDC$), on the grounds that all three angles are equal. Students also succeeded in writing the applicable formal formula, namely $\frac{AB}{ED} = \frac{BC}{DC}$. Then, students substituted the measurement data, namely *BC = 6.3 meters*, *ED = 1.6 meters*, *DC = 1 meter*, and *CG = BF = 1.5 meters* . After calculating the formula, they got *AB = 10.08 meters* and the height of the flagpole *AF =*

AB + BF = 11.58 meters. From these results, it is clear that students understood the problem and were able to solve it correctly.

Realistic Mathematics Education Flow in Indoor and Outdoor Classrooms

Based on the description above, we can make a model of a collaborative RME for indoor and outdoor classrooms, which can be seen in Figure 7.

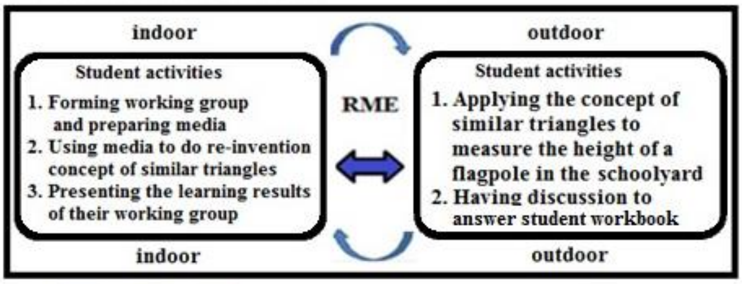


Figure 7. Model for collaborative RME flow in indoor and outdoor classrooms

From Figure 7, we can see that there are three stages of the collaborative RME flow in indoor and outdoor classrooms. The first stage is learning in the classroom. Here, the teacher guides students to do the following activities: (1) collaboration by forming study groups, (2) finding the concept of triangle similarity using graph paper media; and (3) answering questions in SW 1. In the second stage, learning is continued with learning mathematics in outdoor classroom. In outdoor classroom, at the schoolyard, to be exact, the teacher guides students to do the following activities: (1) collaborating to apply the concept of similarity of triangles to measure the height of the flagpole, and (2) having discussion to solve problems in SW 2. In the third stage, all students return to the class. At this stage, the teacher guides students in presenting the results of group work.

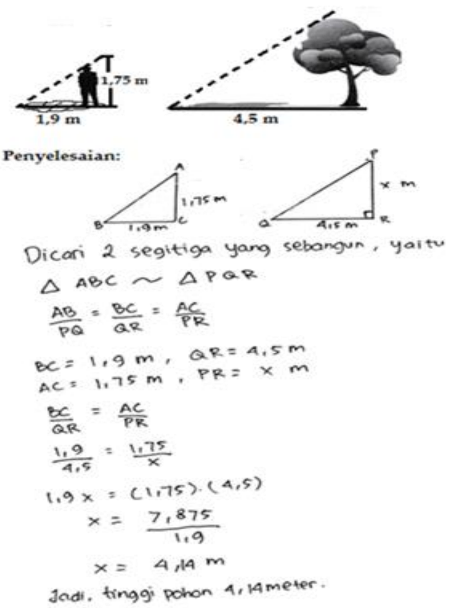
The Effectiveness of Application of Collaborative RME in Indoor and Outdoor Classrooms on Students' MCA

To determine students' MCA, students had pre-test and post-test in the form of four descriptive questions on the concept of triangle similarity that should be completed within 60 minutes. The score of the test results can be seen in the Table 4.

Table 4. Pre-test and post-test scores

Score of Students' MCA N = 17	Pre-test	Post-test
Average	57.47	93.88
Standard Deviation	9.08	5.12
Maximum Score	75	100
Minimum Score	45	85
N-Gain Score	= (93.88-57.47)/(100-57.47) = 0.86	

Based on Table 4, the results of the pre-test were very low, with a minimum score of 45 and a maximum score of 75, and an average of 57.47. The post-test scores were very good, with the average score of 93.88, the minimum score of 85, and the maximum score of 100. All students passed with 5 students (29.4%) being able to achieve the maximum score (100). The N-Gain score of 0.86 shows that the application of learning with a collaborative RME approach in indoor and outdoor classrooms is very effective in improving students' MCA, especially in terms of the topic of similar triangles (Sundayana, 2015). The following is an example of the results of student work in solving problem number 4, which is the problem of the topic of similar triangles, which can be seen in Figure 8.



A person 1.75 m tall is standing near a tree. The length of the shadow is 1.9 m, and the length of the tree's shadow is 4.5 m. What is the height of the tree (x)?

Solution:

1) Draw 2 similar triangles: $\Delta ABC \sim \Delta PQR$,

2) Write the ratio of the corresponding sides, namely $\frac{AB}{PQ} = \frac{BC}{QR} = \frac{AC}{PR}$.

3) Choose a pair of suitable comparisons, namely $\frac{BC}{QR} = \frac{AC}{PR}$.

4)Substituting data into formulas

5) Obtaining the height of the tree (x) = 4.14 meters.

Figure 8. Example of student answer in post-test

Based on Figure 8, it can be seen that the students managed to solve the problem well. Students were able to see two similar triangles, namely $\Delta ABC \sim \Delta PQR$, then students wrote the ratio of the corresponding sides, namely $\frac{AB}{PQ} = \frac{BC}{QR} = \frac{AC}{PR}$. Next, students chose equation that can be used to answer questions, namely, $\frac{BC}{QR} = \frac{AC}{PR}$. After substituting the data, the tree height *(x)* is *4.14 meters* .

From student learning activities, the students activities in making mathematical connections can be described, as shown in Figure 9.

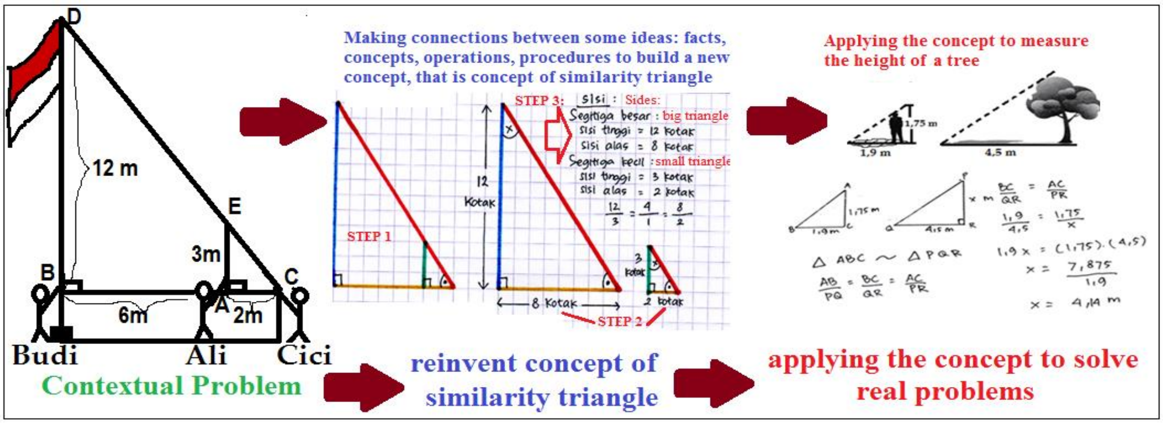


Figure 9. Students activities in making mathematical connections on the topic of similar triangle

From Figure 9, it can be explained that students performed mathematical connections, which included (1) recognizing mathematical ideas related to contextual problems, (2) relating these ideas to produce new concept, and (3) applying this new concept to solve real problems. In the first activity, students in groups identified facts/data obtained from contextual problems, namely, the shape of (large and small) right triangles, the size of the sides of the triangles, and a right angle in both triangles. In the second activity, students collaborated to relate these facts by making representations of two similar triangles separately and relating them with the concept of comparison. Then, they found the ratios of the congruent sides and the measure of the corresponding angles are the same. From these findings, they could build a new concept, namely the concept of similar triangles. In the third activity, students were able to apply the new concept to be used in solving problems. The three mathematical connection activities are in accordance with the collaborative RME principle where students are guided in groups to learn mathematics starting with understanding contextual problems using real objects or models to produce abstract concepts (Astuti, Hartono, Bunayati, & Indaryanti, 2017; Zulkardi, & Putri, 2019). Then, with a combination of learning in indoor and outdoor classrooms, students are guided in groups to apply these concepts in solving problems in mathematics and problems in everyday life, such as the problem of determining the height of a flagpole and the height of a tree (Pambudi, 2022).

Responses or Opinions of Students and Teachers

Students' responses or opinions on the application of collaborative RME learning in indoor and outdoor classrooms were obtained from questionnaires and interviews. Students' answers to the questionnaire can be seen in Figure 10.

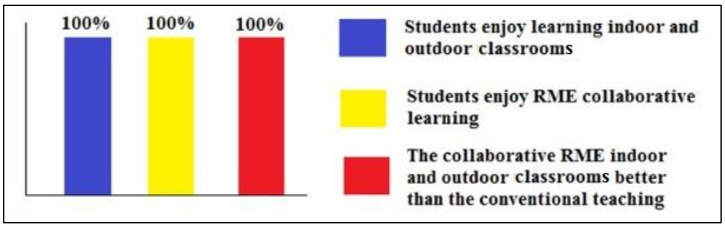


Figure 10. Student responses to learning

From Figure 10, all students (100%) enjoyed participating in collaborative RME learning in indoor and outdoor classrooms and they considered this learning model to be better than the conventional teaching used by teachers.

To deepen the students' responses, interviews were conducted with the group leaders from 3 groups of students. The excerpt of the interview can be seen in Table 5.

(Note: R=Researcher Question, LG1=Leader Group 1 Answers, LG2= Leader Group 2 Answers, LG3= Leader Group 3 Answers).

Table 5. Snippets of interviews with students

Researcher Questions and Students Answers					
R	:	Why do you think the learning you just took was better than usual?	LG2	:	No, Sir, we just needed to carefully measure so that the calculation would be correct.
LG1	:	Because we are happier [with outdoor learning] and it is more fun to learn outside the classroom, Sir....	LG3	:	No, Sir, we just needed more time, so we did not [eventually] rush.
R	:	What do you think about it, LG2?	R	:	Now, tell me, what did you do when you solved the post-test?
LG2	:	Because we now know that mathematics is useful for life, for example to measure the height of a flagpole.	LG1	:	I understood the problem. Then, I used the triangle similarity formula to calculate the tree height using the cross multiplication formula and comparisons.
R	:	What about you, LG3?	R	:	What about you LG2?
LG3	:	Because we can practice measuring the height of the flagpole in the school yard, and learning in outdoor classroom is more exciting, Sir.	LG2	:	Sir, I made a sketch. After that, I wrote the formula for the similarity of the triangles, ...next I calculated the height of the tree.
R	:	How did you [and your group] measure the height of the flagpole when you studied in outdoor classroom? Try LG1, tell your group!	R	:	What about you, LG3?
LG1	:	We understood the SW Sir, then we shared the tasks...some held wooden sticks, attached ropes, and some wrote down the measurement results in the SW. Then we had discussion to calculate the height of the flagpole using the triangle similarity formula.	LG3	:	[I did the] same [procedure] Sir, I read the problem, drew a sketch, wrote down the data according to the problem, then I wrote the triangle similarity formula,...then calculated the tree height by cross multiplication, and comparison.
R	:	What about LG3 group?	R	:	After you did this study, do you like math more now than before?

Researcher Questions and Students Answers					
LG3	:	[I performed the] same [procedure], Sir, as the LG1 and LG2 [did]....	LG1	:	Yes Sir, now we like math [more] than [we did] before.
R	:	Do you think there are any difficulties during the practice outside the classroom?	LG2	:	That's right, Sir, we [became] fonder of math.
LG1	:	No, Sir, [I] just needed cooperation with all group members.	LG3	:	From now on, we want to learn math [more diligently], Sir.

Based on Table 5, the response of students showed that the collaborative RME learning is better than conventional learning. The reasons for students include: (1) students are happier, develop interest, and are not bored in learning mathematics, (2) students not only learn theory, but also can practice directly outside the classroom, (3) students know the benefits of mathematics to solve problems outside the classroom, and (4) students become fonder of mathematics and desire to learn mathematics more diligently. The results of the interviews regarding how the activities of each group in measuring the height of the flagpole were the same as the results of observations made by researchers and teachers where each group shared tasks for all group members; some held the flagpole hoist rope, some held the string at right angles, some held wooden sticks, and some noted down the measurement results on a notebook; then they had discussion to calculate the height of the flagpole using the triangle similarity formula and fill in the students' Workbook. Based on the results, it can be concluded that students and teachers responded positively and supported the application of collaborative RME in indoor and outdoor classrooms, especially regarding the topic of similar triangles.

The results of this study support theory of RME by giving contextual problems at the beginning of learning (Van den Heuvel-Panhuizen & Drijvers, 2014; Zulkardi & Putri, 2019) using the context of "measuring the height of the flagpole" that is very real and very close to the reality of students. Learning mathematics with the RME approach is proven to be able to facilitate students in doing the "re-invention" process, i.e., finding the concept of triangle similarity using media, such as graph paper. The use of collaborative learning also guides students to do the learning process with "intertwining" multi-way interaction and use graph paper and flagpoles as "models of" (the contextual issue) and produce a "model for", which is a triangle similarity formula. This is in accordance with the opinion that the use of RME is able to make all students actively participate in the mathematics learning process with a high degree of activity (Ardiyani, Gunarhadi, & Riyadi, 2018; Hasibuan, Saragih, & Amry, 2019).

More specifically, RME is proven to be able to improve students' MCA (Haji, Abdullah, Maizora, & Yumiati, 2017; Menanti, Sinaga, & Hasratuddin, 2018). When students go through the reinvention process using graph paper, they are able to recognize concepts and relate the concepts that have been studied to find new concepts (Febriyanti, Bagaskorowati, & Makmuri, 2019; Hasbi, Lukito, & Sulaiman, 2019). Then, students apply the concept of similarity of triangles that they have just discovered to be used in solving mathematical problems related to everyday life. The problem is in the form of measuring the height of the flagpole directly in the school yard and the problem of measuring the height of a tree in a written test question. The results of this study are the same as those of Cahyono & Ludwig (2018); and Elpina, Syarifuddin, & Yerizon (2020), which revealed that students understand the benefits of learning mathematics for daily-life problem solving.

The results of this study support the experiential learning theory and the outdoor learning method. Providing a practical learning experience directly by asking the students to measure the height of the flagpole in the schoolyard has proven to provide many benefits to students. These benefits include students knowing the relationship between mathematical concepts and their application in solving mathematical problems outside the classroom (Ball & Bass, 2000; Moss, 2009). In addition, learning like this can increase the sense of care among students to keep the environment around them clean and beautiful and improve the physical and mental health of students. Students can also learn on the move, walk from one place to another, and breathe fresh air. Learning in outdoor classroom clearly makes students happy (Waite, 2011; Richmond, Sibthorp, Gookin, Annarella, & Ferri, 2017), thus making students refreshed and mentally healthy (Acar, 2015).

The use of collaborative RME learning in indoor and outdoor classrooms is also able to improve students' communication and social skills. This is in accordance with the results of previous studies (Hossain, Tarmizi, & Ayub, 2012; Laal, & Ghodsi, 2012). All group members were also able to adapt and learn to socialize with other group members. Students seemed to start to have the courage to speak, express their opinions, and work together to complete the tasks given by the teacher, both in indoor and outdoor classrooms (Harun & Salamuddin, 2014).

The results of this study also support the theory of meaningful learning (Novak, 2011). This can be seen from the observation of student activities during learning. When students learn to use conventional methods, students only learn material that is provided by the teacher, without knowing what the meaning of the material is. This is different when students participate in collaborative RME learning in indoor and outdoor classrooms (Vallori, 2014; Sharan, 2015) where students collaborate in study groups and can connect the knowledge they already have to find the concept of triangle similarity. In addition, students understand the meaning of the relationship between the concepts they learned and their application, which is to measure the height of the flagpole in the outdoor environment outside the classroom. The knowledge that students gain is very real, meaningful and long-lasting in students' minds, even becoming an unforgettable experience throughout their lives (Polman, Hornstra, & Volman, 2020).

Learning in indoor and outdoor classrooms is also able to increase students' attitudes toward (Hossain, Tarmizi, & Ayub, 2012) and interest in mathematics (Laal, & Ghodsi, 2012), which in turn can increase students' motivation and learning outcomes in mathematics. Intrinsic and extrinsic motivation of students caused by the learning atmosphere in indoor and outdoor classrooms is clearly a positive energy that is able to move students to take part in mathematics learning with pleasure and generate high willingness to learn (Tohidi & Jabbari, 2012), so that the post-test socres were very high (Pintrich, 2003).

The application of mathematics learning with collaborative RME in indoor and outdoor classrooms are able to improve students' cognitive, affective, and psychomotor aspects in the mathematics learning process (Kellert, 2002; Smarter Scotland Scottish Government, 2010). In terms of cognitive aspect, students' MCA and student learning outcomes increased (Fagerstam & Blom, 2012). In terms of affective aspect, students become fonder of learning mathematics (Legault, 2016). Regarding psychomotor aspect, students' physical activity also becomes more visible, for example, measuring the distance between two places (Laurens, Batlolona, & Leasa, 2018; and Thomas, 2018).

As an implication of the results of this study, all junior high school mathematics teachers need to apply this teaching approach in schools, both on triangle similarity material and other relevant materials. Other researchers should be able to conduct further research on other topics at other levels of education such as elementary school or high school.

CONCLUSION

Based on the research results, it can be concluded that the mathematics learning using a collaborative RME approach that is conducted in indoor and outdoor classrooms is effective in improving students' MCA. The students' MCA that has been improved is the ability to recognize mathematical ideas related to contextual problems, relate these ideas to produce new concept, and apply this new concept to solve problems in mathematics and daily life. All students gave a positive response. They support the implementation of collaborative RME learning in indoor and outdoor classrooms. All students stated that this kind of learning is better than conventional learning. The advantages of this learning are that it makes students enjoy the learning process, know the benefits of mathematics for daily-life problem solving, and increase interest in learning mathematics. As an implication of the results of this study, all junior high school mathematics teachers need to apply this teaching approach in schools, both on triangle similarity material and other relevant materials. Future study should be able to continue with similar study on other topics, at other levels of education such as elementary or high school.

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