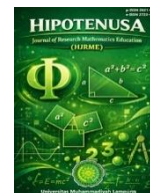


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Implementation of the rme model using the ctl approach on mathematics learning outcomes

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ABSTRACT

Mathematics instruction in high school continues to face the challenge of low student achievement, particularly regarding the abstract concept of tangents to circles. This situation indicates that the learning process has not fully connected mathematical concepts to students' real-life contexts, resulting in suboptimal conceptual understanding. This study aims to determine the effectiveness of applying the Realistic Mathematics Education (RME) model with the Contextual Teaching and Learning (CTL) approach in improving students' mathematics learning outcomes. This study uses a quantitative approach with a one-group pretest–posttest experimental design. The research subjects were 33 students in class XI-6 at SMA Negeri 3 Kediri. Data collection was conducted through pretest and posttest assessments. The data were analyzed using descriptive statistics, a normality test, a paired-sample t-test, and an N-Gain test. The results showed that the average pretest score of 44.55 increased to 80.00 on the posttest. The results of the paired-sample t-test showed a significance level of less than 0.05, indicating a significant difference between learning outcomes before and after the intervention. The N-Gain value of 0.62 falls into the moderate category. These findings suggest that the implementation of the RME model with the CTL approach is effective in improving students' mathematics learning outcomes and helps students better understand the concept of tangent lines to a circle.

1. Introduction

One factor influencing students' mathematical representation skills relates to their prior knowledge, namely the knowledge and skills they have acquired before learning new material [1]. This prior knowledge plays a crucial role in helping students understand new concepts and connect them to what they already know. Mathematics itself is formed through human thought processes involving ideas, reasoning, and logical structures [2]. Mathematics education is a vital component of

the educational system as it fosters students' logical, critical, systematic, and analytical thinking skills [3]. This is because mathematics does not stem solely from observation but from ideas, processes, and deductive proofs, thereby enabling the development of various thinking skills through mathematics education [4]. Through this learning, students are expected to be able to understand concepts, reason mathematically, and apply the knowledge gained to solve problems in daily life [5]. However, many students still struggle to understand mathematical concepts and view mathematics as a complex subject, which results in low student achievement

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The core objective of mathematics education in schools is to enable students to apply mathematics in their daily lives and in studying other subjects, as well as to foster a logical, critical, and creative mindset, along with attitudes such as consistency, honesty, objectivity, precision, and discipline. To achieve these objectives, mathematics instruction should begin by presenting problems rooted in real-life situations closely related to students' experiences, then guide them toward building an understanding of mathematical concepts, principles, and rules, ultimately enabling them to apply these in solving everyday problems using mathematics [7]. However, in reality, low mathematics achievement is closely tied to a teaching process that remains teacher-centered. Learning dominated by lecture methods and routine problem-solving exercises causes students to tend to be passive and focused solely on memorizing formulas. Consequently, students lack a deep understanding of mathematical concepts and struggle when faced with contextual problems [8]. This situation highlights the need for innovative teaching methods that can connect mathematical concepts with students' real-life experiences to make learning more meaningful.

The topic of tangent lines to circles is one of the key areas of mathematics at the high school level that requires abstract thinking skills and a solid conceptual understanding. In this topic, students are expected to understand the concept of tangent lines to circles, identify the relationship between the line and the circle, and apply this concept to various contextual problems. Based on initial observations at State High School 3 Kediri, it was found that students still have difficulty understanding the concept of tangent lines to circles and their application in daily life. This is evident from the low learning assessment scores and the lack of active student participation during the learning process.

Learning models play an important role in facilitating teachers in organizing classroom learning processes, ranging from preparing teaching materials, media, and learning aids to utilizing evaluation instruments to ensure that learning objectives are achieved [9]. In this context, the use of varied teaching methods has been shown to have a positive impact on improving mathematics learning outcomes [10]. One instructional model considered capable of addressing this issue is Realistic Mathematics Education (RME). Previous studies have shown that the application of the RME approach results in higher literacy achievement

compared to conventional learning [11], [12]. The RME model views mathematics as a human activity; therefore, mathematics instruction should begin with real-world problems that are relevant to students' lives [13]. Through RME, students are encouraged to rediscover mathematical concepts through horizontal and vertical mathematization processes [14]. These processes allow students to build a gradual and meaningful understanding of concepts [15].

The Contextual Teaching and Learning (CTL) approach aligns with the characteristics of RME because it emphasizes the connection between learning materials and students' real-life contexts [16]. The CTL approach helps students connect the knowledge learned in class with real-life situations, making learning more relevant and meaningful [17], [18]. With this approach, students not only understand concepts theoretically but are also able to apply them in their daily lives [19-25].

A number of previous studies have shown that the application of the Realistic Mathematics Education (RME) model or the Contextual Teaching and Learning (CTL) approach, when used separately, can improve students' conceptual understanding and mathematics learning outcomes. However, research combining the RME model with the CTL approach in mathematics instruction remains limited, particularly regarding the topic of tangents to circles at the high school level. Therefore, this study applies the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach in teaching tangents to circles. The integration of these two approaches is expected to create mathematics learning that is more active, meaningful, and student-centered. Through learning that connects mathematical concepts to real-life contexts, students are expected to more easily understand the material on tangents to circles, thereby improving their learning outcomes.

Based on the above discussion, this study aims to determine the effectiveness of implementing the Realistic Mathematics Education (RME) model with the Contextual Teaching and Learning (CTL) approach in improving students' mathematics learning outcomes on the topic of tangents to circles at State Senior High School 3 Kediri.

2. Method

2.1. Research design

This study employed a quantitative method with an experimental design using a one-group pretest-posttest design. The objective of this study was to analyze the effectiveness of implementing the

Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach on students' mathematics learning outcomes, particularly on the topic of tangent lines to circles. The design involved a single group, where students were given a pretest before the treatment and a posttest after the implementation of the RME model with the CTL approach [26].

2.2. Research Setting and Participants

The research was conducted at SMA Negeri 3 Kediri during the academic year 2024/2025. The population of this study consisted of students in grade XI. The participants were selected using a purposive sampling technique. This technique was used to select a class that met the research criteria. Based on this consideration, class XI-6, consisting of 33 students, was chosen as the research sample. This class was selected as the experimental group that received learning using the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach.

2.3. Development Procedure

The procedure for executing this research followed systematic stages:

1. Preparation Stage

The researcher prepared the learning outcome test instrument in the form of essay questions designed to measure students' understanding of the concept of tangent lines to circles. The instrument was validated by experts and tested for validity and reliability before being used in the study.

2. Implementation Stage

The research was conducted in one experimental class. The learning process was carried out using the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach. The learning activities began with presenting contextual problems related to students' daily lives, followed by group discussions to construct mathematical concepts through horizontal and vertical mathematization processes.

3. Evaluation Stage

After the learning process, students were given a posttest to measure their learning outcomes. The results of the posttest were then compared with the pretest scores to analyze the improvement in students' understanding.

2.4. Instruments and Data Collection

The instrument used in this study was a mathematics learning outcome test consisting of 5 essay questions. The test was administered in the form of pretest and posttest to measure students' improvement in understanding. Before the research, the instrument underwent a trial (*try out*) to determine:

1. Validity

Content validity was assessed using validation sheets by mathematics education experts and lecturers. Item validity was analyzed to ensure that each question measured the intended concept appropriately.

2. Difficulty Level

The level of difficulty of each item was analyzed to ensure that the questions were neither too easy nor too difficult. A good test item should have a moderate level of difficulty so that it can effectively differentiate students' abilities.

3. Reliability

Reliability testing was conducted using Cronbach's Alpha to measure the consistency of the instrument. The results indicated that the instrument had a high level of reliability and was suitable for use in this study.

2.5. Data Analysis

The data analysis techniques included:

1. Prerequisite Tests: Normality tests were conducted using the Shapiro-Wilk test to determine whether the data were normally distributed as a requirement for further statistical analysis.
2. Hypothesis Testing: Hypothesis testing was carried out using the paired sample t-test with a significance level of 5% to determine whether there was a significant difference in students' learning outcomes before and after the implementation of the Realistic Mathematics Education (RME) model with the Contextual Teaching and Learning (CTL) approach.
3. N-Gain Test: The N-Gain test was used to measure the improvement in students' learning outcomes. The results were categorized into high (≥ 0.70), moderate ($0.30-0.69$), and low (< 0.30) levels of improvement [20].

3. Results and discussion

3.1. Analysis Stage

The analysis stage aimed to evaluate the quality of the research instrument before it was used in the study. The instrument consisted of 5 essay questions designed to measure students' understanding of the concept of tangent lines to circles [27-30].

The instrument was first validated by experts to ensure content validity. The validation results indicated that all items were appropriate and relevant to the learning objectives. Furthermore, reliability testing was conducted using Cronbach's Alpha, which resulted in a coefficient of 0.732. This value indicates that the instrument has a high level of reliability and is suitable for use in this study.

3.2. Design Stage

In this stage, the instrument was analyzed based on its level of difficulty. The purpose of this analysis was to ensure that the test items could effectively measure students' abilities. The results showed that all test items were categorized at a moderate level of difficulty. This indicates that the instrument was neither too easy nor too difficult, making it appropriate for distinguishing students' understanding levels. Therefore, the instrument met the criteria of a good test and was suitable for use in the data collection process [31].

3.3. Development Stage

The development stage involved testing the assumptions required for statistical analysis. In this study, the normality test was conducted using the Shapiro–Wilk test.

Table 1
Normality Test Results

Data	N	Shapiro-Wilk	Sig.
Pretest	33	0.981	0.816
Posttest	33	0.841	0.000

Based on Table 1, the pretest data show a significance value greater than 0.05, indicating that the data are normally distributed. Although the posttest data show a significance value less than 0.05, the analysis was continued considering the robustness of the paired sample t-test.

3.4. Implementation Stage

This stage presents the results of the implementation of the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach.

Table 2
Pretest, Posttest, and N-Gain Results

Description	Score
Mean Pretest	44.55
Mean Posttest	80.00
Standard Deviation	35.45
N-Gain	0.62
Category	Moderate

Based on Table 2, the average pretest score of 44.55 indicates that students' initial understanding was still low. The relatively high standard deviation shows that students' abilities varied significantly. After the implementation of the learning model, the average posttest score increased to 80.00, indicating a substantial improvement in students' understanding [32]. To determine whether this improvement was statistically significant, a paired sample t-test was conducted.

Table 3
Paired Sample t-test Results

Statistic	Value
Sig. (2-tailed)	0.000
Significance Level	0.05
Result	Significant

Based on Table 3, the significance value is less than 0.05, indicating that there is a significant difference between students' learning outcomes before and after the implementation of the RME model with the CTL approach. The N-Gain value of 0.62 falls into the moderate category, which indicates that the improvement in students' learning outcomes is meaningful.

3.5. Evaluation Stage

The results of this study indicate that the implementation of the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach is effective in improving students' mathematics learning outcomes. This effectiveness can be attributed to the characteristics of RME, which emphasizes learning through real-life contexts. Students are actively involved in solving contextual problems and are encouraged to construct

their own understanding through horizontal and vertical mathematization processes. The CTL approach further strengthens learning by connecting mathematical concepts with students' daily experiences. This makes learning more meaningful and helps students understand concepts more deeply rather than relying on memorization [33].

The improvement in learning outcomes, as indicated by the moderate N-Gain and significant t-test results, shows that students not only improve procedurally but also conceptually. These findings are consistent with previous studies that show the effectiveness of RME and CTL in improving students' conceptual understanding and learning outcomes. Therefore, the integration of RME and CTL can be used as an effective alternative learning strategy. However, this study has limitations, as it was conducted in only one class with a limited number of participants and focused on a single topic. Therefore, further research is recommended to involve larger samples and different mathematical topics.

4. Conclusion

This study concludes that the implementation of the Realistic Mathematics Education (RME) model combined with the Contextual Teaching and Learning (CTL) approach has a positive and significant effect on students' mathematics learning outcomes. The results showed a significant improvement in students' learning outcomes, as indicated by the increase in the average score from 44.55 in the pretest to 80.00 in the posttest. The paired sample t-test results also confirmed a significant difference between learning outcomes before and after the implementation of the learning model. In addition, the N-Gain value of 0.62 indicates a moderate level of improvement, suggesting that the learning process supports not only procedural understanding but also conceptual understanding.

The findings indicate that the integration of RME and CTL creates a meaningful learning experience by connecting mathematical concepts with real-life contexts and encouraging active student participation. Therefore, this model can be considered an effective alternative for improving students' understanding of mathematical concepts, particularly in abstract topics such as tangent lines to circles. However, this study is limited to a single class and focuses only on one mathematical topic. Future research is recommended to involve larger samples and different mathematical materials in order to obtain more comprehensive results.

CRedit authorship contribution statement

Tiara Ayu Linggar Sari: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Writing – original draft. **Bambang Agus Sulistyono:** Supervision, Validation, Writing – review & editing. **Samijo:** Supervision, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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