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Application of a Realistic Mathematics Education Approach Through Flip Learning in Mathematics Learning in Schools

Akmal Rijal[1]✉, Dodik Mulyono[2]
[1]University of PGRI Silampari, Indonesia

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Abstract

This study examines the differences in student learning outcomes after mathematics instruction using an integrated PMR approach and flipped learning on circle material. Method: True experiment involving 86 students with different backgrounds in terms of ability and gender. Data analysis includes descriptive statistics, normality testing, and independent two-sample t-tests. Findings: The PMR approach with flipped learning not only improves student learning outcomes but also positively contributes to students' mathematics learning outcomes.

Keywords: Learning Outcomes, Flip Learning, Realistic Mathematics Education.

Penerapan Pendekatan Pendidikan Matematika Realistis Melalui Flip Learning Pada Pembelajaran Matematika di Sekolah

Abstrak

Penelitian ini mengkaji perbedaan hasil belajar siswa setelah pengajaran matematika dengan pendekatan PMR terintegrasi dan flip learning materi lingkaran. Metode: True eksperimen diikuti oleh 86 siswa dengan perbedaan latar belakang kemampuan dan jenis kelamin. Analisis data meliputi statistik deskriptif, pengujian normalitas, dan uji-t dua sampel independen. Temuan: Pendekatan PMR dengan flip learning tidak hanya meningkatkan hasil belajar siswa tetapi juga berkontribusi positif terhadap hasil belajar matematika siswa.

Kata kunci: Hasil Belajar, *Flip Learning*, Pendidikan Matematika Realistik.

✉*Corresponding Author: Akmal Rijal*
Affiliation Address: Universitas PGRI Silampari, Lubuklinggau, Sumatera Selatan, Indonesia.
E-mail: akmalrijal@unpari.ac.id

INTRODUCTION

Mathematics is one of the most important sciences and forms the foundation for other disciplines. Its importance is evident in including mathematics education from elementary school to higher education (Rijal & Azimi, 2021). To enable children to think critically, rationally, analytically, methodically, creatively, and cooperatively, mathematics instruction is crucial (Mattoliang et al., 2022). Mathematics is a vital auxiliary science useful daily and supports advancing science and technology (Fiangga et al., 2021). It is a means of fostering logical, systematic, objective, critical, and rational thinking, which must be nurtured from primary education (Rudyanto et al., 2019). Therefore, mathematics should serve as a tool to enhance students' reasoning abilities and their capacity to face daily challenges.

The results of the 2022 Programme for International Student Assessment (PISA) in mathematics, where 15-year-olds scored 366 points as opposed to the OECD average of 472 points, bring attention to the problem of mathematical education for Indonesian students. Just 18% of Indonesian pupils attained a minimum proficiency level in mathematics, which is significantly below than the OECD average of 69%. Without explicit teaching, pupils at this minimal level are able to comprehend and identify how straightforward problems can be represented mathematically. With an OECD average of 9%, very few Indonesian pupils achieved the top scores (levels 5 or 6) on the PISA mathematics exam (Wijaya et al., 2024). At these levels, students are able to choose, assess, and compare suitable approaches to addressing problems as well as mathematically represent complex situations (Syutaridho et al., 2023).

The low level of mathematical problem-solving skills among Indonesian junior high school students is another issue with mathematics education, which can be related to a number of variables (Sugiarto et al., 2021). These include the perception that the material is abstract and uninteresting due to a lack of real-life examples, teacher-centered teaching methods, passive student participation, and an approach focused on repetitive practice, arithmetic skills, and memorizing steps or formulas (Uegatani et al., 2023). For students to effectively navigate a variety of problems in mathematics, other topics, and an increasingly complex daily life, they must be able to solve mathematical puzzles. However, in practice, students' mathematical learning capabilities remain low, with little likelihood of improvement (Harisman et al., 2023). This is because mathematics teaching is still heavily textbook-focused, with teachers adhering to traditional teaching steps: presenting learning material, providing example problems, and having students work on exercises from textbooks (Maulina et al., 2020).

To address these issues, one effort is to introduce variations in classroom teaching. Current mathematics education is less meaningful, making students passive, bored, and disinterested in mathematics (Fauzana et al., 2020). Therefore, it is necessary to have a teaching strategy that is simple to comprehend, relevant, appealing to kids, and intimately tied to their surroundings. Realistic Mathematics Education (RME) is a method that emphasizes student-centered learning by utilizing real-world situations and activities to link students' everyday experiences with mathematical principles (Bayu et al., 2023). RME encourages students to search for, discover, and construct their knowledge, making learning more engaging and centered on students, this approach also brings meaningful mathematics teaching by relating it to real-life situations (Syafriafdi et al., 2019).

Through RME, students can develop their mathematical problem-solving skills (Zubaidah et al., 2021). By engaging in problem-solving activities, students are motivated to address questions that guide them through the problem-solving process (Voigt et al., 2020). Typically, contextual problems are often found at the end of teaching sessions and seen merely as enrichment of the material learned, in RME, contextual problems are placed at the beginning of the lesson, serving as triggers for students to rediscover mathematical concepts (Yuniati et al., 2020). Schools implementing RME show better outcomes than those that do not because RME fosters active student participation and engagement, furthermore, in solving problems, students can apply their unique ideas and opinions (Syutaridho et al., 2023).

High-achieving students in RME schools significantly outperform those in non-RME schools in mathematical problem-solving (Putri et al., 2023). However, low-achieving students in RME schools do not show better performance than those in non-RME schools (Maulina et al., 2020). The implementation of RME generally follows specific steps: selecting realistic contexts, orienting students to contextual problems, exploring models, developing mathematical models, applying them in other contexts, and assessing through final reflections (Palinussa et al., 2021). RME encourages students to actively participate in the learning process by utilizing real-world settings. By following these steps, students can get a deeper understanding of mathematical ideas as well as the critical and creative thinking abilities needed to solve problems in the real world (Juandi et al., 2022).

The main objective of the learning process is for students to comprehend the subject content. Consequently, it is essential to employ instructional methodologies that facilitate the application of mathematics in practical settings, making use of technology as a cutting-edge, contemporary learning tool (Hafni et al., 2022). The role of media is vital in ensuring that the material delivered by the teacher is quickly and effectively understood by students (Sampoerno & Meiliasari, 2019). In order to attain fundamental competences, learning activities should offer experiences involving mental and physical processes through interactions between students, teachers, the environment, and other learning resources (Tomory, 2023). These learning experiences should be tailored to the conditions and interests of the students, incorporating essential life skills (Onyishi & Sefotho, 2020). Hence, the essence of learning is the process of how learning occurs within the students. Five key components influence student success: instructional materials, learning environment, media or teaching aids, learning resources, and the teacher as the instructor (Estaiteyeh & DeCoito, 2023). Using technology in teaching can facilitate students' mathematical problem-solving activities, technology allows students to explore problem-solving strategies creatively (Waluyo, 2020). Therefore, a learning model that actively involves students and enhances their learning outcomes is necessary.

The choice of teaching models significantly impacts the quality of learning outcomes. Thus, teachers must select appropriate teaching models to create an optimal learning process. A teaching model is a method of presenting material in a learning process conducted by the teacher for students, structured in a way or technique to achieve learning objectives (Brigandi et al., 2019). This study introduces a teaching model that can be applied in the teaching process to address these issues: the flipped learning model. Flipped learning transforms classroom activities into more interactive experiences, such as discussions, Q&A sessions, and problem-solving (Mudiarta et al., 2021). This approach shifts the teacher's role from information provider to learning facilitator. Flipped learning combines traditional classroom teaching with modern technology-based learning outside the classroom. Activities include providing instructional materials through videos, and quizzes, and guiding students during discussions and presentations, culminating in projects (Tomory, 2023). For flipped learning to be effective, a learning management system is used to support its implementation (Campanella, 2022).

The implementation of flipped learning involves creating and providing instructional materials such as educational videos, quizzes, and exercises. Teachers then guide discussions and presentations by explaining concepts, solving exercises, or facilitating small projects related to the material (Joo & Park, 2023). Teachers design projects requiring student collaboration to apply mathematical concepts in real or simulated situations. Practical activities where students apply mathematical concepts directly, like experiments or educational games, are arranged (Senthilkumar, 2019). The final step is to provide evaluation and feedback. The benefits of flipped learning in mathematics education include increased student engagement, fostering student responsibility for their learning, development of collaboration, communication, and critical thinking skills through projects and presentations, and more effective use of classroom time for deep discussions, problem-solving, and practical applications rather than mere information delivery (Mahapatra et al., 2021). Flipped learning involves various activities that facilitate deep and interactive student learning. By presenting material through videos and quizzes and guiding students in discussions and projects, teachers help students achieve better understanding and relevant skills for their future (Zainuddin et al., 2022). Flipped learning offers an innovative approach to mathematics education that can enhance student engagement and comprehension. With proper preparation and support, this model can be effectively implemented in junior high schools (Song, 2020).

Combining the RME approach with the flipped learning model for teaching circle material to junior high school students can create a more interactive and meaningful learning experience (Song, 2020). The steps to implement these approaches include preparing or selecting a video explaining basic circle concepts, such as radius, diameter, circumference, and area, using real-life examples. Relevant real-life situations include calculating the circumference and area of a playground or bicycle wheel. Students explore by working in groups to draw circles and try calculating the circumference and area using simple tools like string and rulers. Students discuss with the teacher facilitating class discussions where each group shares their methods and results. Developing mathematical models involves helping students formulate the formulas for circumference and area based on their explorations. The concepts are then applied to other contexts, such as calculating the area of a circular sports field or the circumference of a swimming pool. Assessment involves providing an online quiz with practice problems in class to evaluate student understanding. Combining RME with flipped learning in teaching circle material offers a deep and contextual learning experience for students. Learning through real-world contexts and using class time for discussions and practical applications enables students to develop a better understanding and stronger critical thinking skills (Fredriksen, 2021).

Scientific articles on curriculum development and mathematics teaching design often focus on conceptual mathematical theories without integrating technology-based learning models to deepen real-life applications (Phan et al., 2022; Nguyen et al., 2020; Revina & Leung, 2019; Prahmana et al., 2020). However, they lack concrete cases and empirical analysis of how specific curriculum developments and course design impact student achievement and learning outcomes. Additionally, criticism is often directed at teachers for lacking the specialized knowledge needed for the target material. In mathematics, there is debate on whether teachers should only teach formulas and calculations within limited contexts (Juandi et al., 2022). The literature on RME and technology-based teaching methods does not sufficiently provide examples in the field of technology-based mathematics teaching design. Therefore, bridging the gap between literature and teachers' needs in instructional design, this study highlights a mathematics teaching design based on the concepts of "realistic mathematics education" and "flipped learning," involving ICT integration and skill integration in an Indonesian school. The primary goal of this research is to develop and explore student learning outcomes after studying circle material using the RME approach with flipped learning at State Junior High School in Indonesia. The main research question is whether the RME approach with flipped learning results in different learning outcomes for students who apply this approach compared to those who do not.

METHODS

True experimental designs method the post-test control and experimental group design (Cohen et al., 2018), conducted at State Junior High School 3 Lubuklinggau, Indonesia. 344 eighth-grade students from State Junior High School, distributed among 8 classes with varied ability levels (70% female and 30% male), make up the study's population. Cluster random sampling was used to choose the sample, with class VIII E (consisting of 42 students) chosen as the experimental group and class VIII B (consisting of 44 students) chosen as the control group, for a total of 86 individuals. For the instrument test to measure learning outcomes, class VIII A was used. The validity of each question was determined using the product-moment correlation formula, with 30 questions calculated using Pearson product-moment correlation, with the value of r table (n=30) of 0.212 at the 5% threshold. Each test question scored between 0.324 and 0.930. The reliability of the questions was determined to be 0.929 using Cronbach's Alpha. The sample has similar characteristics in terms of school support resources and average student ability (intake).

In this study, statistical analysis was used to examine the experimental and control groups. The study contrasted the experimental class's learning results, which utilized the RME approach with flip learning for teaching circle material, and the control class, which followed conventional learning methods. The study began with the development and validation of a draft design concept for the RME approach with flip learning in teaching circle material through a forum group discussion with mathematics education experts (Syafriafdi et al., 2019; Zarista et al., 2020). The next stage was to administer the treatment for one semester (6 months) in the even semester of the 2023–2024 academic year at State Junior High School in both the experimental and control courses, in classes VIII E and VIII B. For the experimental group, the material was designed according to the RME approach with flip learning for the circle material.

Making a film that explains the fundamental ideas of a circle, including its radius, diameter, circumference, and area using real-world contextual examples was one of the phases involved in integrating the RME technique with flip learning in the teaching of circle subject. Students calculated the circumference and area of playgrounds or bicycle wheels. Students explored by working in groups to draw circles and calculate the circumference and area using simple tools like string and rulers. Students discussed their methods and results in class discussions facilitated by the teacher. They formulated formulas for the circumference and area of circles based on their explorations and applied these in other contexts, such as calculating the area of circular sports fields or the circumference of swimming pools. Assessment was conducted using online quizzes and classroom exercises to evaluate students' understanding. The instruments used in this study were test questions and document studies. There were thirty questions in all, all in multiple-choice format. Every test item received a score of 1 for accurate responses and 0 for inaccurate ones. Data on the cognitive learning outcomes of the students in the experimental and control groups were gathered using the questions.

Descriptive statistics were employed in this study's data analysis to ascertain the average, assess data normality, and test the hypothesis using an independent two-sample t-test (Cohen et al., 2018). In order to investigate the research questions and determine whether there was a statistically significant difference in learning outcomes between students in the experimental and control classes who used the RME approach with flip learning and those who did not, an independent two-sample t-test was performed (Waluyo, 2020).

FINDINGS AND DISCUSSION

With the help of flip learning, this study intends to design and investigate the learning outcomes that students at State Junior High School 3 Lubuklinggau, Indonesia, will experience after studying circular content using the RME approach. If the RME technique combined with flip learning in mathematics instruction can raise students' performance in the subject more successfully than traditional methods and if it helps students meet the minimal mastery requirements, then it is seen to have an impact on learning outcomes. Table 1 below provides information on student learning outcomes based on test results for the circle topic.

Table 1. Student learning outcomes with the RME approach and flip learning

Class	N	Average	Maximum	Minimum
Experiment	42	67.7381	96	24
Control	43	58.0714	83	28

It is known from Table 1 that the average score is 67, the lowest score is 24, and the maximum score is 96. Half of the students in the experimental group scored more than 67.7381, while the other half scored lower, as indicated by the average score of 67.7381. Nearly half of the experimental group students scored 66, which is below the range, exceeding the maximum score of 96 and the minimum score of 24, and still within that interval. This indicates that the student's answers are heterogeneous, suggesting that there was no cheating, especially collaboration, during the test.

The average score in the control group is 58.0714, with the greatest score being 83 and the lowest being 28. These scores fall within the mastery criteria for mathematics learning. Half of the control group students scored above 60.500, and half scored below 60.500. Most control group students scored within the range, with the maximum score of 83 and the minimum score of 28 still within that interval. This indicates that the student's answers are heterogeneous, suggesting that there was no cheating, especially collaboration, during the test.

In the eighth grade at State Junior High School 3 Lubuklinggau, hypothesis testing for student learning outcomes in mathematics instruction utilizing the Realistic Mathematics Education approach with flip learning on circular material yields better results than conventional instruction. Using class VIII E as the experimental group and class VIII B as the control group, a two-sample t-test was employed to demonstrate this. Table 2 below displays the t-test results for the two classes.

Table 2. T-test output for two-sample t-test of student learning outcomes with RME approach and flip learning

	Levene's Test for Equality of Variances		T-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference Std. Error Difference	Mean Difference Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Class VIII E and class VIII B equal variances assumed	.189	.665	3.007	82	.003	9.66667	3.2145	3.27210	16.06123
Class VIII E and class VIII B equal variances not assumed			3.007	81.994	.003	9.66667	3.2145	3.27209	16.06124

The column labeled "Levene's test for equality of variances" in Table 2, which displays the t-test output for the two-sample t-test of student learning outcomes with the Realistic Mathematics Education approach and flip learning, reveals a F value of 0.189 and a significance (sig.) value of 0.665, both of which are greater than 5%. The variances of the learning outcomes for the experimental class VIII E and the control class VIII B are therefore the same, supporting the hypothesis. Assuming equal variances, the null hypothesis is rejected since the sig. (2-tailed) value obtained is 0.003, which is less than 5%. This conclusion suggests that the experimental class VIII E and the control class VIII B had different learning outcomes. The experimental class's average learning outcome is 67.7381, whereas the control class's average is 58.0714. This validates the study's hypothesis, which claims that eighth-grade math students who use the Realistic Mathematics Education approach get higher learning results than students who use traditional teaching techniques when it comes to the topic of circles.

It is possible to draw the conclusion that eighth-grade mathematics instruction utilizing the RME approach in conjunction with flip learning about circles satisfies the efficacy requirements based on the findings of the study and the analysis carried out, as previously detailed in the previous chapters. The average learning outcomes meeting the mastery requirements for circles demonstrate that the learning outcomes on this topic support this finding. When compared to traditional learning approaches, the learning outcomes based on the RME approach with flip learning on the topic of circles are superior. The average learning outcome for mathematics in the experimental class was 67.7381, whereas the control class's average was 58.0714.

Assuming equal variances, the null hypothesis is rejected since the sig. (2-tailed) value obtained is 0.003, which is less than 5%. Given that the average learning outcome of the experimental class, 67.7381, is different from the control class, 58.0714, it may be concluded that there is a difference in learning outcomes between the experimental class VIII E and the control class VIII B. This is consistent with the research question, which asks whether students who use the RME technique with flip learning in eighth grade mathematics achieve higher learning outcomes than students who use traditional approaches while learning about circles. This study therefore establishes a significant improvement in student learning outcomes in mathematics learning when the RME approach is combined with flip learning. The results of this study suggest that this strategy improves students' learning outcomes in mathematics compared to traditional methods; it also achieves minimum mastery standards, enhances process skills, and shows a positive association between learning outcomes and student involvement.

The experimental class's student score distribution is highly variable, with 96 being the highest and 24 being the lowest. This suggests that the test was administered honestly and without cheating because the learning outcomes are varied. The same conclusion is supported by the control class, which likewise exhibits a varied score distribution with a maximum score of 83 and a lowest score of 28. The fact that this study was limited to 86 pupils in one school and had a small sample size (86 students) limits its generalizability to groups with similar characteristics to those of the school.

The results imply that mastery is demonstrated by learning using the RME approach in conjunction with flip learning. It is advised to use the RME strategy with flip learning more frequently to further enhance learning outcomes. Enhancing learning environments and infrastructure is also necessary, as is producing more inventive and creative learning materials. Because of the rapid breakthroughs in technology, traditional teaching techniques are no longer as effective for mathematics courses. Education should take use of these developments. Educational facilities and infrastructure should adapt to technological advancements. Thus, the findings of this study could pioneer future research in this field. However, it is worth comparing these findings with previous studies that explored each element or skill. For example, the findings support the positive impact of applying the Web's realistic math approach to improving students' learning outcomes (Amelia et al., 2020; Mutaqin et al., 2021). These findings also support the integrated effects of the flip learning method on the development of mathematical skills (Rifandi et al., 2023; Uyen et al., 2021), mathematical problem solving (Harisman et al., 2023; Putri et al., 2023; Sugiarto et al., 2021), mathematical concepts (Apsari et al., 2023; Haji & Yumiati, 2021), mathematical literacy and increasing understanding of mathematical concepts through digital technology (Fauzana et al., 2020; Fredriksen, 2021; Hafni et al., 2022), and the positive effects of student's communication skills and attitudes (Kutluca & Gündüz, 2022; Palinussa et al., 2021; Tong et al., 2021).

CONCLUSION

Overall, this study shows that combining flip learning with the RME approach to mathematics instruction can significantly enhance student learning outcomes. This method is not better than traditional approaches, but it also improves student involvement and process abilities, which in turn raises math achievement levels. As a result, it makes sense to implement and improve this strategy in classroom mathematics instruction. In addition to enhancing student learning results, the RME technique with flip learning satisfies the minimal mastery requirements.

This method also improves student engagement and process abilities, both of which are beneficial to the learning outcomes of mathematics. This study has several drawbacks, including the fact that it was limited to one school and had a relatively small sample size (86 students). As a result, these findings can only be applied to groups that share the same traits as the institution under study. It is advised to use the RME approach in conjunction with flip learning more widely to improve learning outcomes. In addition, more inventive and creative learning material need to be developed, as well as better infrastructure and facilities for learning.

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