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Fostering Mathematics Learning Engagement through Differentiated Teaching: Evidence from Classroom Action Research

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ABSTRACT

Purpose of the study: This study aimed to examine the effectiveness of differentiated teaching in fostering mathematics learning engagement and improving mathematics achievement among secondary school students with diverse academic abilities through the implementation of classroom action research in a collaborative learning environment.

Methodology: This study employed a classroom action research design conducted in two cycles involving 35 tenth-grade students of Madrasah Aliyah Pembangunan UIN Jakarta. Data were collected using mathematics learning engagement observation sheets, formative tests, interview guidelines, field notes, and documentation. Descriptive statistics and qualitative coding techniques were used, while data trustworthiness was established through triangulation procedures.

Main Findings: The findings showed that students' mathematics learning engagement increased from 67.61% in Cycle I to 81.11% in Cycle II. The mean score improved from 5.39 to 6.76, while learning mastery increased from 34.3% to 63.0%. Standard deviation decreased from 2.57 to 1.50. Peer tutoring, handouts, quizzes, challenge tasks, and reward systems supported active participation and improved mathematics achievement.

Novelty/Originality of this study: The novelty of this study lies in integrating differentiated teaching with cooperative learning mechanisms supported by peer tutoring, handouts, challenge tasks, quizzes, and reward systems to foster mathematics learning engagement. Unlike previous studies emphasizing achievement outcomes, this study highlights learning engagement as the primary focus while addressing students with diverse academic abilities.

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1. INTRODUCTION

Mathematics learning plays an essential role in developing students' critical thinking, problem-solving, and reasoning abilities needed to face increasingly complex challenges in the twenty-first century. However, students enter classrooms with diverse characteristics, including differences in readiness, interests, and learning profiles [1], [2]. Such diversity requires teachers to provide learning experiences that accommodate students' various needs and potentials. Contemporary learning paradigms emphasize student-centered instruction that

promotes active participation and meaningful learning experiences [3], [4]. Therefore, learning approaches that recognize and respond to learner diversity are increasingly important in mathematics education.

Despite the importance of student engagement, mathematics learning in many classrooms is still dominated by teacher-centered practices. Students are often positioned as passive recipients of information and are mainly involved in listening, taking notes, and completing exercises [5], [6]. This condition limits opportunities for students to actively construct mathematical understanding and participate meaningfully in the learning process. Consequently, low levels of learning engagement may negatively affect students' academic achievement and the development of higher-order thinking skills [7], [8]. Addressing this issue requires instructional approaches that encourage active involvement and accommodate students' diverse learning needs.

Previous studies have demonstrated that differentiated teaching contributes positively to improving students' academic performance, motivation, and participation in classroom activities. Research has also highlighted the effectiveness of cooperative learning strategies in promoting interaction and collaboration among students [9]. Furthermore, differentiated instruction has been recognized as an approach capable of addressing differences in students' readiness and learning preferences. However, many previous studies have primarily focused on learning outcomes and cognitive achievement rather than examining students' engagement during mathematics learning [10], [11]. As a result, empirical evidence concerning the role of differentiated teaching in fostering mathematics learning engagement remains limited.

In addition, studies integrating differentiated teaching with cooperative learning strategies within the framework of Classroom Action Research are still relatively scarce. Existing research tends to emphasize general classroom implementation without providing detailed evidence regarding changes in students' learning engagement across action cycles [12], [13]. Moreover, limited attention has been given to how differentiated teaching can support heterogeneous learners in secondary mathematics classrooms. This condition indicates the existence of a research gap concerning the practical application of differentiated teaching in promoting students' engagement in mathematics learning [14]. Therefore, further investigation is needed to provide empirical evidence regarding the effectiveness of this instructional approach.

Investigating mathematics learning engagement through differentiated teaching is important because engaged students are more likely to participate actively, collaborate effectively, and achieve better learning outcomes. Enhancing engagement is also essential for creating inclusive learning environments that support students with different levels of readiness and abilities [15]. In addition, differentiated teaching aligns with current educational trends that emphasize personalized and responsive instruction. Understanding how differentiated teaching influences students' engagement may provide valuable insights for teachers in designing more adaptive mathematics instruction [16], [17]. Consequently, this issue has practical significance for improving the quality of mathematics learning in secondary schools.

The novelty of this study lies in its focus on fostering mathematics learning engagement through differentiated teaching implemented with cooperative learning strategies within a Classroom Action Research framework. Unlike previous studies that predominantly examined academic achievement, this study emphasizes students' engagement as a key indicator of instructional effectiveness [18]. Furthermore, the study provides empirical evidence regarding changes in students' engagement throughout iterative action cycles. It also highlights how differentiated teaching can address the diverse readiness levels of students in mathematics classrooms. Therefore, this study contributes to expanding the literature on differentiated teaching and offers practical implications for developing more responsive mathematics instruction.

2. RESEARCH METHOD

2.1 Research Design and Participants

This study employed Classroom Action Research (CAR) to improve students' mathematics learning engagement through differentiated teaching. The study was conducted from October to December 2009 at Madrasah Aliyah Pembangunan UIN Jakarta, Indonesia. The participants consisted of 35 tenth-grade students comprising 20 male students and 15 female students. The research was collaboratively carried out with two teacher collaborators who assisted in observation and documentation activities. The implementation of the study followed iterative cycles consisting of planning, action, observation, and reflection stages [19].

Figure 1: Classroom Action Research Cycle

2.2 Intervention Procedure

The intervention was implemented using differentiated teaching based on students' readiness levels and supported by cooperative learning strategies. Students were grouped flexibly to facilitate discussion,

collaboration, and peer assistance during mathematics learning activities. Each cycle consisted of planning instructional activities, implementing the action, observing students' responses, and conducting reflection to evaluate the effectiveness of the intervention [20], [21]. The findings obtained in one cycle served as the basis for improving the subsequent cycle. The action research process continued until the predetermined indicators of success were achieved.

2.3 Data Collection Instruments

Data were collected using both test and non-test instruments to obtain comprehensive information regarding students' learning engagement and learning outcomes [22]. The test instrument consisted of an end-of-cycle formative test designed to measure students' mathematics achievement. Non-test instruments included observation sheets, interview guidelines, field notes, and documentation records. The observation instrument focused on visual, oral, writing, drawing, and mental activities demonstrated by students during the learning process. In addition, interviews were conducted to obtain supporting information concerning students' responses toward differentiated teaching practices.

Table 1. Indicators of Mathematics Learning Engagement

Dimensions	Indicators
Visual Activities	Paying attention to teacher and peers' explanations
Oral Activities	Asking questions, discussing, and responding
Writing Activities	Taking notes and completing assignments
Drawing Activities	Constructing graphs and representations
Mental Activities	Analyzing and solving mathematical problems

2.4 Data Analysis and Trustworthiness

Quantitative data obtained from students' engagement scores and formative test results were analyzed using descriptive statistics in the form of percentages, means, and standard deviations. Qualitative data derived from observations, interviews, and field notes were analyzed through coding and descriptive interpretation. The combination of quantitative and qualitative analyses enabled a comprehensive understanding of students' learning engagement throughout the intervention process. To ensure the trustworthiness of the findings, triangulation techniques were employed by comparing information obtained from different instruments and sources. The study considered the action successful when students' mathematics learning engagement reached at least 75% and most students achieved the minimum mastery criterion.

3. RESULTS AND DISCUSSION

3. Improvement of Mathematics Learning Engagement

The implementation of differentiated teaching through cooperative learning strategies showed a positive impact on students' mathematics learning engagement. Data collected from observation sheets indicated that students became more actively involved in classroom discussions and collaborative activities. The average percentage of mathematics learning engagement increased from the first cycle to the second cycle. Improvements were particularly evident in students' participation, questioning behavior, and interaction among peers. These findings suggest that differentiated teaching created a more responsive learning environment that accommodated students with diverse learning abilities.

Table 2. Improvement of Students' Mathematics Learning Engagement

Cycle	Mean Percentage (%)	Increase (%)
Cycle I	67.61	-
Cycle II	81.11	13.50

Based on Table 2, the average level of learning engagement increased by 13.50 percentage points from Cycle I to Cycle II. The engagement level in Cycle II exceeded the predetermined success criterion of 75%, indicating that the intervention effectively enhanced students' participation during mathematics learning. The findings demonstrate that differentiated teaching supported active learning and promoted collaborative interactions among students. Students were increasingly willing to discuss, ask questions, and contribute to group activities. Therefore, the intervention successfully fostered mathematics learning engagement.

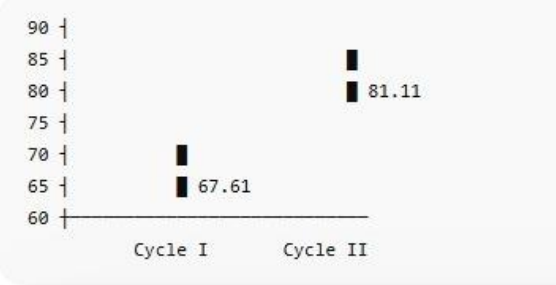

Figure 2. Improvement of Mathematics Learning Engagement Across Cycles

3.2 Improvement of Mathematics Achievement

Besides improving learning engagement, differentiated teaching also contributed to students' mathematics achievement. The results of formative tests demonstrated that students' academic performance improved after revisions were implemented in the second cycle. Additional quizzes, peer tutoring, and reward systems encouraged students to participate more actively and strengthened their understanding of mathematical concepts. Consequently, the average score and the percentage of learning mastery increased substantially. Furthermore, the distribution of students' scores became more homogeneous, as indicated by the decrease in standard deviation.

Table 3. Descriptive Statistics of Mathematics Achievement

Statistics	Cycle I	Cycle II
Mean Score	5.39	6.76
Standard Deviation	2.57	1.50
Learning Mastery (%)	34.3	63.0
Highest Score	10.0	9.8
Lowest Score	1.76	3.9

The results presented in Table 3 reveal that the mean score increased from 5.39 in Cycle I to 6.76 in Cycle II. Similarly, the percentage of students achieving mastery improved from 34.3% to 63.0%. Meanwhile, the standard deviation decreased from 2.57 to 1.50, indicating that students' learning outcomes became more evenly distributed. These findings suggest that differentiated teaching effectively supported students with varying academic abilities. Therefore, the intervention not only enhanced engagement but also improved mathematics achievement.

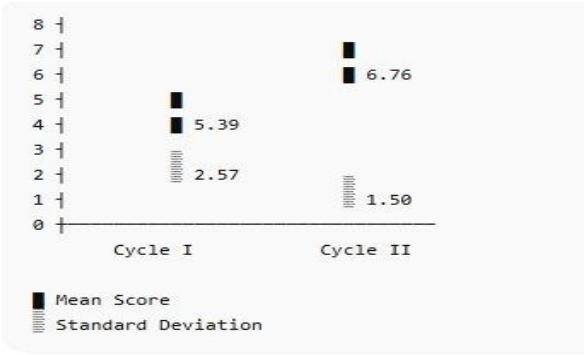

Figure 3. Comparison of Mean Scores and Standard Deviations

3.3 Major Findings of the Study

Several important findings emerged from this classroom action research. First, the use of handouts facilitated students' understanding because the materials were systematically organized and could be reviewed repeatedly. Second, peer tutoring played a crucial role in promoting interaction and encouraging active participation among group members. Third, the provision of rewards increased students' motivation to engage in collaborative learning activities. Finally, the classroom action research process contributed to reducing score variability, indicating that differentiated teaching successfully accommodated students with high, medium, and low academic abilities.

Table 4. Major Findings of the Study

Findings	Evidence
Handouts facilitated learning	Students reported easier understanding and review of materials
Peer tutoring enhanced engagement	More active discussion and interaction among students
Rewards increased motivation	Students became more enthusiastic and competitive
Score variability decreased	Standard deviation declined from 2.57 to 1.50
Learning mastery improved	Mastery increased from 34.3% to 63.0%

The findings of this study demonstrated that differentiated teaching implemented through cooperative learning strategies effectively enhanced students' mathematics learning engagement. The average engagement score increased from 67.61% in Cycle I to 81.11% in Cycle II, indicating an improvement of 13.50 percentage points. Students showed greater participation in discussions, paid more attention to learning activities, and actively interacted with their peers during the learning process. These improvements suggest that differentiated teaching provided learning experiences that were more responsive to students' varying readiness and learning needs. Consequently, the intervention succeeded in creating a more active and collaborative mathematics classroom environment.

In addition to improving learning engagement, differentiated teaching also contributed positively to students' mathematics achievement. The mean score increased from 5.39 in Cycle I to 6.76 in Cycle II, while learning mastery improved from 34.3% to 63.0%. Moreover, the decrease in standard deviation from 2.57 to 1.50 indicated that students' learning outcomes became more evenly distributed across different ability levels. This finding implies that differentiated instruction was capable of supporting not only high-achieving students but also those with medium and low academic abilities. Therefore, the implementation of differentiated teaching promoted both equity and effectiveness in mathematics learning.

The results of this study are consistent with previous studies emphasizing that differentiated instruction provides learning opportunities that accommodate students' diverse characteristics and academic readiness. Earlier research generally reported that differentiated teaching contributes to improved academic performance and classroom participation [23], [24]. Similarly, the present study found that adapting learning activities according to students' needs encouraged greater involvement and understanding of mathematical concepts. The role of cooperative learning and peer interaction further strengthened students' engagement during classroom activities [25], [26]. These findings support the constructivist perspective, which highlights active participation and social interaction as essential elements in meaningful learning.

Despite these similarities, this study offers several distinctive contributions compared with previous research. Most studies on differentiated teaching have focused primarily on learning achievement, whereas the present study places greater emphasis on mathematics learning engagement as the primary outcome. Furthermore, differentiated teaching was implemented through cooperative learning supported by peer tutoring, handouts, challenge tasks, quizzes, and reward systems [27], [28]. Such a combination created a learning environment that encouraged students to actively participate and support one another. Therefore, the novelty of this study lies in integrating differentiated teaching with collaborative learning mechanisms to foster engagement among students with diverse academic abilities.

The findings of this study have important implications for mathematics teachers and educational practitioners. Teachers should recognize that students possess different levels of readiness, interests, and learning profiles, which require flexible instructional approaches [29]. The implementation of differentiated teaching can serve as an alternative strategy to create inclusive and student-centered mathematics classrooms. In addition, peer tutoring and collaborative learning activities can be utilized to encourage active participation and mutual support among students [30], [31]. Consequently, this study provides practical evidence that differentiated teaching can be adopted to enhance both learning engagement and academic achievement in secondary mathematics education.

Several limitations should be acknowledged in interpreting the findings of this study. First, the study involved only one class consisting of 35 students, which limits the generalizability of the findings. Second, the research was conducted using a classroom action research design with only two cycles, making it difficult to observe long-term effects of the intervention. Third, the study focused mainly on learning engagement and achievement without examining other variables such as motivation, self-efficacy, or mathematical reasoning ability. In addition, the findings were obtained within a specific educational context and may differ when implemented in other settings [32]. Therefore, future studies are recommended to involve larger samples, longer intervention periods, and additional variables to provide more comprehensive evidence regarding the effectiveness of differentiated teaching.

4. CONCLUSION

This study concludes that the implementation of differentiated teaching through cooperative learning strategies effectively fostered students' mathematics learning engagement and improved their academic achievement in a classroom characterized by diverse learning abilities. Consistent with the objectives stated in the introduction, the findings demonstrated that differentiated instruction provided an appropriate solution for increasing students' participation, interaction, and understanding of mathematical concepts through flexible and collaborative learning experiences. The improvement in engagement levels, learning mastery, and the more equitable distribution of achievement scores indicate that differentiated teaching successfully accommodated students with varying levels of readiness and learning needs. Furthermore, the integration of peer tutoring, handouts, challenge tasks, quizzes, and reward systems contributed to creating a supportive and inclusive learning environment that encouraged active participation among students. These findings provide empirical evidence that differentiated teaching can serve as an effective pedagogical approach for promoting student-centered mathematics learning in secondary education settings. Therefore, future studies are recommended to extend the implementation of differentiated teaching to larger populations, longer intervention periods, and different educational contexts while exploring additional variables such as learning motivation, self-efficacy, critical thinking, and mathematical reasoning abilities to strengthen the generalizability and practical implications of the findings.

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