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Differentiated instruction based on the PBL model to improve junior high school students' learning outcomes

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Abstract

This study was conducted to improve the learning process and enhance the mathematics learning outcomes of Grade IX. A student at SMP Negeri 2 Kampar Kiri Hilir. The research was motivated by the low attainment of KKTP standards, as most students had not yet met the school's minimum score. To address this issue, differentiated instruction combined with the Problem-Based Learning (PBL) model was implemented. This approach allows students to learn at their individual readiness levels and solve contextual problems. The study employed a Classroom Action Research (CAR) design consisting of two cycles, each including the stages of planning, implementation, observation, and reflection. During the learning process, students were grouped by readiness level and actively participated in discussions. The findings revealed an improvement in the learning process, as evidenced by increased student engagement in discussions and improved learning outcomes, rising from 35% at baseline to 40% in Cycle I and 60% in Cycle II. These results indicate that differentiated instruction based on the PBL model can serve as an effective alternative for improving students' mathematics learning outcomes.

Keywords: classroom action research; learning outcomes; differentiated instruction; problem-based learning

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I. Introduction

According to Elsa (2023), learning outcomes reflect students' performance, as observed through changes in behaviour, skills, attitudes, and cognitive abilities. Such outcomes are typically assessed by students' achievement of the *Kriteria Ketercapaian Tujuan Pembelajaran* (KKTP), as indicated by their scores after completing classroom instruction. The Regulation of the Minister of Education, Culture, Research, and Technology (*Permendikbudristek*) No. 21 of 2022, Article 9 paragraph (8), states that assessment of student learning outcomes must be conducted by comparing students' performance with the predetermined KKTP. Teachers need to recognize students' diverse characteristics and adjust instructional strategies to accommodate their varying learning styles, interests, readiness levels, and learning needs (Rahmania, Noni, & Talib, 2026). In mathematics education, learning is not only intended to develop students' conceptual understanding but also to foster essential competencies such as creativity, critical thinking, collaboration, and communication skills

that are needed in everyday life. (Siregar & Sofyan, 2023). However, not all Grade IX students achieve high learning outcomes across all subjects, particularly in mathematics. A student at SMP Negeri 2 Kampar Kiri Hilir.

An interview with the mathematics teacher of class IX.A revealed that students' mastery of KKTP standards in mathematics remained low. Out of 20 students in the class, many had not yet reached the minimum required score of 75. The primary factor contributing to this low performance, as suggested by Pujiati (2022), is the misalignment between teaching methods and students' characteristics and needs. Each learner has a distinct way of understanding classroom material. To achieve optimal learning outcomes, teachers must ensure that instructional practices are effective for all students by applying appropriate teaching methods.

Interviews were conducted with three Grade IX students. A study of students and the mathematics teacher at a junior high school to explore factors contributing to students' low mathematics achievement. The interviews focused on students' learning experiences, conceptual understanding, learning difficulties, and their ability to solve contextual mathematical problems. The findings revealed that many students had difficulty understanding mathematical concepts presented in class.

Several students reported that mathematics was challenging because they often failed to grasp the concepts the teacher explained, leading to reduced attention and engagement during lessons. This finding was supported by students' learning outcomes, which showed that only 35% achieved the learning objectives for linear equations in one variable, and only 15% achieved the learning objectives for linear inequalities in one variable. Furthermore, students encountered difficulties in identifying relevant information, determining what was being asked, and translating contextual problems into mathematical models. These challenges indicate a limited conceptual understanding, which contributed to students' low achievement in mathematics.

Given these findings, efforts are needed to improve students' learning outcomes. The researcher conducted classroom observations to examine the root causes of this issue further. The observations revealed that during core learning activities, the instructional approach used did not fully align with the principles of learner-centred education as outlined in *Permendikbudristek* No. 16 of 2022. Ideally, teachers should apply learning models suited to students' characteristics, such as Problem-Based Learning (PBL). However, this approach had not been implemented because students were still relatively passive, relying heavily on teacher direction rather than engaging in independent inquiry or critical thinking.

Amira & Agustin (2024) identify that teacher-centred instruction, monotonous learning media, and uniform teaching methods are common challenges in classroom practice. At the secondary level, numerous instructional approaches can enhance the quality of learning, including differentiated mathematics instruction. This approach is particularly relevant, as students often perceive mathematics as a difficult and abstract subject (Syarifah, Anggoro, & Andriani, 2025).

According to Purba, Purnamasari, Soetantyo, Suwarma, & Susanti (2021), differentiated instruction is an approach that adjusts teaching strategies to accommodate students' diverse needs with the aim of maximizing each learner's potential based on their level of learning readiness. Faiz, Pratama, & Kurniawaty (2022) further define differentiated instruction as an approach that addresses individual learning needs by adapting the learning process to students' characteristics. Students' success in learning is influenced by two main factors: internal and external. Internal factors include intelligence, readiness, motivation, interest, and learning autonomy, while external factors encompass instructional models, teachers' attitudes, learning environments, and other

contextual conditions (Daulay, Yuanita, & Suanto, 2023). One essential aspect of differentiated instruction is learning readiness, which refers to students' initial abilities or mastery of prerequisite knowledge before engaging with new learning materials (Adriana, Sari, & Martusyilia, 2025).

Classroom learning becomes more effective when teachers understand their students' unique characteristics, thereby facilitating the achievement of learning objectives (Estari, 2020). Differentiated instruction allows teachers to group students by readiness level and vary learning processes so that each learner can engage meaningfully with the content. Through this approach, students' potential is optimally developed by taking into account their individual needs, characteristics, and achievement levels (Suanto, Siregar, & Hutapea, 2024). As Sutaga (2022) explains, process differentiation focuses on how students construct meaning from what they learn, enabling teachers to design activities that accommodate students' varying needs and abilities.

The implementation of differentiated instruction begins with initial assessments, which may be administered through tests or non-test instruments. Diagnostic assessments, in particular, help teachers design lesson plans that align with students' readiness levels (Subhan, 2022). This step ensures that learning activities are tailored to students' developmental stages and competencies. In the Problem-Based Learning (PBL) model, collaborative learning is implemented, requiring students to interact, share ideas, and work together to identify the most effective solutions.

The problems used as the foundation of learning in the PBL model are primarily drawn from real-life situations that are familiar and easily recognized by students (Suanto, Khainingsih, & Hutapea, 2022). According to Sakti & Luthfiyah (2024), integrating differentiated instruction with the PBL model fosters an effective learning environment that enhances student outcomes. The PBL model encourages collaboration, idea exchange, and problem-solving, while differentiated instruction allows grouping based on readiness levels, thus improving teamwork and overall learning results.

According to Arisandi (2024), differentiated instruction and Problem-Based Learning (PBL) are effective in improving students' mathematics learning outcomes. Differentiated instruction can also enhance students' engagement and achievement by adapting learning activities to their readiness levels (Widana & Kusuma, 2023). Meanwhile, Sitorus, Sitinjak, & Lafau (2023) reported that PBL promotes conceptual understanding, critical thinking skills, and active participation through contextual problem-solving activities in mathematics learning. Similarly, Pratama, Sripatmi, Salsabila, & Hikmah (2024) found that the integration of differentiated instruction and PBL improved both students' academic achievement and classroom participation.

Despite these promising findings, previous studies have generally focused on implementing differentiated instruction or PBL in a broad sense, without specifically examining readiness-based differentiation for the topic of Simultaneous Linear Equations with Two Variables (SLETV) at the junior secondary school level. Furthermore, limited research has examined how differentiated instruction, integrated with PBL, can support students with varying readiness levels in understanding algebraic concepts and solving contextual problems. In response to this gap, the present study implements differentiated instruction integrated with the PBL model in the topic of Simultaneous Linear Equations with Two Variables (SLETV) among Grade IX students. A student at SMP Negeri 2 Kampar Kiri Hilir.

Students were grouped by learning readiness and provided with differentiated worksheets tailored to each group's needs. This study not only examines the impact of the intervention on students' mathematics learning outcomes but also explores how readiness-based differentiation can be facilitated through the

stages of the PBL model. Therefore, the novelty of this study lies in integrating readiness-based differentiated instruction and PBL into SLETV learning within a Classroom Action Research setting, providing empirical evidence of their potential to improve both student participation and mathematics learning outcomes, and to promote active participation among Grade IX students. A student at SMP Negeri 2 Kampar Kiri Hilir.

II. Research Method

This study employed a collaborative Classroom Action Research (CAR) design involving collaboration between the researcher and the mathematics teacher of Grade IX.A. According to Susilo (2022), Classroom Action Research is a reflective research approach conducted through cyclical stages implemented by teachers or prospective teachers in the classroom. It is characterized by a continuous process consisting of planning, action, observation, and reflection aimed at solving instructional problems and introducing innovations to improve the quality of learning (Pahleviannur, 2022).

This study adopted a collaborative approach in which the researcher and the mathematics teacher worked together throughout the implementation of the instructional intervention. The researcher was responsible for designing the instructional materials, developing differentiated lesson plans and student worksheets (LKPD), constructing the research instruments, and analyzing the collected data. Meanwhile, the mathematics teacher served as the classroom observer and provided feedback during the reflection stage. The researcher and the teacher collaboratively conducted classroom observations, discussed the results of each cycle, identified areas for improvement, and planned actions for the subsequent cycle. This collaboration was intended to ensure that the instructional intervention was implemented effectively and aligned with the classroom context and students' learning needs.

Within this collaborative framework, the instructional intervention was carried out through differentiated instruction integrated with the Problem-Based Learning (PBL) model. Prior to the learning activities, students completed a learning readiness assessment to identify their prior knowledge of the topics to be studied. Based on the assessment results, students were grouped into low-, moderate-, and high-readiness levels. Differentiation in this study focused on learning readiness differentiation, enabling learning activities and support to be adjusted according to students' readiness levels.

Differentiation in this study focused on learning readiness differentiation. Each group was provided with student worksheets (LKPD) containing contextual problems of varying difficulty levels, aligned with students' learning readiness. During group discussions, the teacher provided more intensive guidance to students with low readiness levels, while students with moderate and high readiness levels were encouraged to solve problems more independently. Throughout the PBL stages, students analyzed contextual problems, discussed solution strategies, presented their findings, and reflected on the problem-solving process. The research participants were in Grade IX. A student at SMP Negeri 2 Kampar Kiri Hilir. The class was selected based on a preliminary analysis of students' learning outcomes, which indicated that their mathematics achievement was relatively low. In the topic of Linear Equations in One Variable (LEOV), only 35% of students met the Learning Objectives Achievement Criteria (LOAC). In contrast, in the topic of Linear Inequalities in One Variable (LIOV), only 15% met the criteria. These findings suggest that most students had difficulty understanding mathematical concepts and solving contextual problems.

Therefore, Grade IX. A was selected as the research participants because the class required instructional improvement to enhance students' mathematics learning outcomes. To ensure the appropriateness and quality of the

instructional materials for the research context, the lesson plans were developed based on the principles of differentiated instruction and the syntax of the PBL model. The lesson plans, student worksheets, observation sheets, and assessment instruments were validated by two mathematics education experts and one experienced mathematics teacher. The instructional materials were subsequently revised based on the validators' feedback regarding content accuracy, clarity of learning activities, suitability for students' readiness levels, and alignment with the research objectives. Therefore, the instructional materials were considered appropriate and feasible for implementation in the target classroom.

The research was conducted in Class IX. A of SMP Negeri 2 Kampar Kiri Hilir during the first semester of the 2025/2026 academic year. The participants consisted of 20 students, 10 male and 10 female. The intervention implemented in this study was the application of differentiated instruction combined with the Problem-Based Learning (PBL) model on the topic of Simultaneous Linear Equations with Two Variables (SLETV). Differentiated instruction in this study was based on students' learning readiness levels.

Based on the results of the learning readiness assessment, students were grouped homogeneously by readiness level and provided with worksheets (LKPD) tailored to each group's needs. According to Fauzi, Usman, Hayati, & Nasihudin (2023), homogeneous grouping is an effective strategy for addressing the diversity of students' learning readiness levels in the classroom. This strategy was implemented to facilitate readiness differentiation by adapting learning activities to students' readiness levels. By providing appropriate support and challenges, students were expected to participate more actively in the learning process and achieve the intended learning objectives.

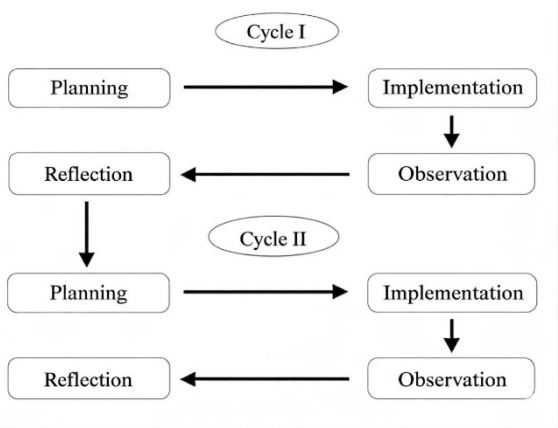

Figure 1. Classroom action research cycle model

According to Arikunto (2021), Classroom Action Research consists of four stages in each cycle: planning, implementation, observation, and reflection. This study was conducted during the first semester of the 2025/2026 academic year, from August 26, 2025, to September 17, 2025. It was implemented over eight scheduled mathematics learning sessions rather than throughout the entire semester. The study consisted of two cycles, with each cycle comprising two learning meetings and one formative test. Accordingly, the research followed this Classroom Action Research model, which includes the stages of planning, action, observation, and reflection.

This study was conducted in two cycles. Each cycle consisted of two meetings, followed by Arikunto (2021), and one formative test. Thus, the research followed the Classroom Action Research model, which includes four stages: planning, action, observation, and reflection. Two cycles were implemented to provide an opportunity to revise and improve the instructional intervention based on the reflection results from the previous cycle. The first cycle was used to identify weaknesses in the implementation of differentiated instruction integrated with the PBL model. In contrast, the second cycle was conducted to refine the instructional practices and achieve the expected improvement in students' mathematics learning outcomes.

The research instruments included observation sheets for both teacher and student activities to assess the implementation of learning. The observation sheets are presented in the following figure.

No	Fase	Aspek yang Diamati
Kegiatan Pendahuluan:		
1		Guru meminta siswa berdoa sesuai dengan kepercayaan masing-masing dipimpin oleh ketua kelas.
		Guru menanyakan kehadiran siswa.
		Guru meminta siswa mempersiapkan perlengkapan dan peralatan yang diperlukan untuk pembelajaran.
2		Guru menginformasikan materi yang akan dipelajari pada pertemuan tersebut.
3		Guru memberikan pemahaman bermakna dengan menjelaskan pentingnya materi dengan membahas manfaatnya dalam kehidupan sehari-hari.
4		Guru memberikan pertanyaan pemantik kepada siswa.
5		Guru menyampaikan tujuan pembelajaran yang harus dicapai dan kegiatan pembelajaran yang akan dilakukan.
6		Guru membentuk kelompok belajar siswa sesuai dengan tingkat kesiapan belajar siswa, meminta siswa untuk duduk di dalam kelompok, dan membagikan LKPD kepada siswa.
Kegiatan Inti:		
7	Fase 1: Orientasi siswa pada masalah	Guru mengarahkan siswa untuk mengamati dan memahami masalah yang disajikan di LKPD.
		Guru mendorong siswa untuk bertanya tentang apa yang belum mereka pahami dari masalah.
8	Fase 2: Mengorganisasikan siswa untuk belajar	Guru meminta siswa untuk berdiskusi memahami permasalahan yang disajikan di LKPD.
9	Fase 3: Membimbing penyelidikan individu dan kelompok	Guru mengarahkan siswa untuk mengumpulkan informasi yang sesuai dengan penyelesaian masalah yang diberikan pada LKPD.
		Guru membimbing siswa berdiskusi bersama kelompok terkait penyelesaian dari permasalahan pada LKPD berdasarkan informasi yang diperoleh.
10	Fase 4: Mengembangkan dan menyajikan hasil karya	Guru mengarahkan siswa menyiapkan bahan hasil diskusi kelompok untuk dipresentasikan.
		Guru melakukan undian dan meminta perwakilan kelompok terpilih untuk mempresentasikan hasil diskusi kelompok di depan kelas.
11	Fase 5: Menganalisis dan mengevaluasi proses pemecahan masalah	Guru meminta siswa dari kelompok lainnya menanggapi jawaban kelompok penyaji.
		Guru menyatukan pendapat dan mengevaluasi hasil pemecahan masalah pada LKPD.
Kegiatan Penutup:		
12		Guru membimbing siswa mengemukakan kesimpulan materi pembelajaran.
13		Guru memberikan tes formatif kepada siswa untuk dikerjakan secara individu.
14		Guru melakukan refleksi kepada siswa terhadap pembelajaran yang telah berlangsung.
15		Guru memberikan Pekerjaan Rumah (PR) kepada siswa dan menginfokan kepada siswa tentang materi pertemuan selanjutnya.
16		Guru menutup pelajaran dan berdoa.

Figure 2. Teacher activity observation sheet

No	Fase	Aspek yang Diamati
		Kegiatan Pendahuluan:
1		Siswa berdoa menurut kepercayaan masing-masing dipimpin oleh ketua kelas. **(Beriman dan Bertaqwa Kepada Tuhan Yang Maha Esa)**
		Siswa memberikan informasi kehadiran.
		Siswa mempersiapkan perlengkapan dan peralatan yang diperlukan untuk pembelajaran.
2		Siswa menyimak pemahaman bermakna yang disampaikan oleh guru tentang pentingnya materi yang akan dipelajari.
3		Siswa menyimak pertanyaan pemantik yang diberikan oleh guru.
4		Siswa menyimak penjelasan guru tentang tujuan pembelajaran yang harus dicapai dan kegiatan pembelajaran yang akan dilakukan.
5		Siswa duduk dalam kelompok yang dibentuk oleh guru.
		Kegiatan Inti:
6	Mengorientasi siswa pada masalah	Siswa mengamati dan memahami masalah yang diberikan guru pada LKPD. **(Berpikir Kritis)**
		Siswa mengajukan pertanyaan tentang hal-hal yang belum dipahami dari masalah.
7	Mengorganisasikan siswa untuk belajar	Siswa dalam kelompok berdiskusi memahami permasalahan pada LKPD. **(Bergotong Royong)**
8	Membimbing penyelidikan individu dan kelompok	Siswa mengumpulkan infromasi yang sesuai dengan penyelesaian masalah yang diberikan pada LKPD. **(Bergotong Royong)**
		Siswa berdiskusi untuk mengolah informasi yang diperoleh dan mendiskusikan rencana penyelesaian dari permasalahan pada LKPD. **(Bergotong Royong)**
		Siswa melaksanakan rencana penyelesaian permasalahan yang diberikan dalam LKPD. **(Bergotong Royong)**
9	Mengembangkan dan menyajikan hasil karya	Siswa menyiapkan bahan hasil diskusi kelompok untuk dipresentasikan.
		Siswa mempresentasikan hasil diskusi kelompok di depan kelas.
10	Menganalisis dan mengevaluasi proses pemecahan masalah	Siswa memberi tanggapan terhadap jawaban kelompok penyaji.
		Siswa menyimpulkan penyelesaian masalah pada LKPD.
		Kegiatan Penutup:
11		Siswa mengemukakan kesimpulan materi pembelajaran.
12		Siswa mengerjakan tes formatif secara individu.
13		Siswa melakukan refleksi bersama guru terhadap pembelajaran yang telah berlangsung.
14		Siswa menyimak informasi tentang Pekerjaan Rumah (PR) dan materi pertemuan selanjutnya.
15		Siswa berdoa untuk menutup pembelajaran. **(Beriman dan Bertaqwa Kepada Tuhan Yang Maha Esa)**

Figure 3. Student activity observation sheet

Instructional materials, such as the differentiated teaching module, LKPD, and learning outcome test, were administered at the end of each cycle to measure students' mastery of the learning objectives according to the Learning Objectives Achievement Criteria (LOAC/KKTP). The test consisted of two essay questions that assessed indicators of conceptual understanding, mathematical modelling, and problem-solving skills related to Simultaneous Linear Equations with Two Variables (SLETV). The test items were developed based on the learning objectives, achievement indicators, and the content taught during the implementation of the instructional intervention.

Prior to implementation, the test instrument was validated by two mathematics education experts and one experienced mathematics teacher to ensure content validity, language clarity, and alignment with the learning objectives. The instrument was subsequently revised based on the validators' feedback before being administered to the students.

The test results were analyzed by calculating the average score and the percentage

of students who achieved the Learning Objectives Achievement Criteria (LOAC/KKTP) in each cycle. The learning outcome test was one of the primary indicators of improvement because it directly measured students' mastery of the mathematical concepts and skills targeted during instruction. Improvements in the average scores and mastery percentages from Cycle I to Cycle II were used to determine the effectiveness of differentiated instruction integrated with the Problem-Based Learning (PBL) model in enhancing students' mathematics learning outcomes.

A reflection was conducted after each cycle to identify weaknesses or limitations in the implementation of actions. The results of reflection from cycle I were used to improve the implementation in Cycle II. The criteria for success were defined by two indicators: an increase in student learning activities and an increase in the proportion of students meeting the KKTP benchmark.

III. Results and Discussion

The implementation of differentiated instruction based on the Problem-Based Learning (PBL) model for the topic of Systems of Linear Equations in Two Variables (SLETV) successfully improved the learning process. It enhanced the mathematics achievement of Grade IX. A student at SMP Negeri 2 Kampar Kiri Hilir. In Cycle I, students were grouped according to their learning readiness levels and participated in learning activities following the stages of the Problem-Based Learning (PBL) model. During the problem orientation and investigation phases, several students, particularly those in the low-readiness group, had difficulty understanding contextual problems and constructing mathematical models. Student participation in discussions and presentations was also relatively low. The reflection results indicated the need for more intensive guidance and improved facilitation during group discussions.

Based on these reflection findings, several improvements were implemented in Cycle II, including more intensive attention, clearer guidance, and increased teacher support throughout the learning process. As a result, students demonstrated more active participation in discussions, better collaboration within groups, and greater confidence when presenting their work. Students were also better able to analyse contextual problems and determine appropriate solution strategies. These findings suggest that implementing differentiated instruction integrated with the PBL model contributed to improvements in both student participation and mathematics learning outcomes.

This classroom action research (CAR) was conducted in the first semester of the 2025/2026 academic year and involved 20 students (10 male and 10 female) as research subjects.

Implementation of The Intervention

Before implementing the intervention, the researcher and the mathematics teacher collaboratively designed the learning process based on the principles of differentiated instruction and the Problem-Based Learning (PBL) model. The researcher was primarily responsible for developing the lesson plans, differentiated student worksheets (LKPD), observation sheets, and learning outcome tests. At the same time, the mathematics teacher provided input regarding students' characteristics, classroom conditions, and the suitability of the learning activities for the research setting. Through several collaborative discussions, both parties determined the readiness-based grouping strategy, the contextual problems to be used in the worksheets, and the learning activities implemented at each stage of the PBL model.

To ensure the quality and appropriateness of the instructional design, the lesson plans, LKPD, observation sheets, and assessment instruments were reviewed and validated by two mathematics education experts and one experienced mathematics teacher. The instructional materials were subsequently revised based on the validators' recommendations regarding content accuracy, clarity of instructions, alignment with students' readiness

levels, and consistency with the research objectives. The finalized instructional design was then implemented during the intervention stage.

The study consisted of two cycles, each comprising four stages: planning, implementation, observation, and reflection. Cycle I was carried out from August 26 to September 3 2025, while Cycle II took place from 10 to September 17 2025, with each cycle including two 2×40-minute learning sessions and one 2×40-minute summative assessment. In the planning stage, the researcher prepared learning tools, including Learning Objective Flow, Teaching Modules, differentiated Student Worksheets (LKPD), teacher and student activity observation sheets, and summative assessment items with answer keys.

Before Cycle I, a diagnostic assessment was administered to map students' readiness levels in SLETV, resulting in three homogeneous groups: high (7 students), medium (6 students), and low (7 students). The implementation phase followed PBL syntax: (1) problem orientation, (2) organizing students into groups, (3) guiding group investigation using LKPD tailored to readiness levels, (4) presenting solutions, and (5) conducting joint analysis and reflection. The researcher acted as the teaching practitioner, the classroom teacher as the observer of teacher activities, and a mathematics education student as the observer of student activities.

Analysis of Teacher and Student Activities

Observation sheet data showed a clear improvement in the quality of the learning process from Cycle I to Cycle II, as summarized in Table 1 (Teacher and Student Activities). The increased scores in teacher and student activity indicate that the steps of differentiated PBL learning were implemented more consistently and that students became more engaged and active in discussions from one cycle to the next.

Table 1. Teacher and student activities

Learning Activities	Analysis Results	
	Cycle I	Cycle II
Preparing students physically and psychologically	Students began the lesson with a prayer and greetings. The teacher checked attendance and students' learning readiness, and asked students to prepare their learning materials	The activities of prayer, greetings, attendance checking, and preparation for learning were conducted in an orderly and effective manner.
Giving motivation	The teacher motivated students by relating the learning material to everyday life.	The teacher delivered motivation using communicative language, which increased students' enthusiasm.
Conducting Apperception	Apperception was conducted by recalling the previous material; however, only a small number of students actively responded.	Students actively responded to the apperception and confidently expressed their opinions.
Communicating learning objectives	The learning objectives were presented using PowerPoint; however, some students were still not fully focused.	The learning objectives were clearly communicated, and students paid close attention.
Explaining learning activities	The teacher explained the learning activities using PowerPoint; however, only some students paid attention.	Students attentively followed and understood the planned learning activities.
Forming learning groups	Students were grouped based on their learning readiness; however, the grouping process was still less	The formation of learning groups based on students' learning readiness was carried out within an orderly,

	orderly during the initial meeting.	supportive learning environment.

Based on Table 1, the analysis of teacher and student activities during the preliminary stage indicates a significant improvement across various aspects of the learning process. In Cycle I, the researcher attempted to involve students in the initial learning activities, such as conducting apperception and explaining the learning objectives. However, only a small proportion of students actively responded or asked questions. In Cycle II, student engagement during the preliminary activities increased noticeably. Students became more active in responding to the apperception, leading prayers, and paying close attention when the researcher explained the learning objectives. This improvement demonstrates enhanced student engagement and better learning readiness compared to the previous cycle.

Table 2. Teacher and student activities in cycles I and II during the core learning activities

Learning Activities	Analysis Results	
	Cycle I	**Cycle II**
Students' orientation toward problems	Students examined the problem presented in the LKPD; however, they engaged in limited questioning and demonstrated incomplete comprehension.	Students focused on observing the problem and actively asked questions to understand the issue comprehensively
Organizing students in learning activities	Students struggled to identify known facts and questions embedded in the problem.	Students successfully identified given data and inquiries independently.
Guiding students in individual and group investigation	Group cooperation remained suboptimal, with students overly reliant on peers.	Students engaged in active discussions, effective collaboration, and autonomous information gathering under teacher guidance.
Developing and presenting the work	Discussion presentations were confined to reading aloud, accompanied by low student self-confidence	Students delivered clear, confident presentations of their discussion outcomes.
Analyzing and evaluating problem-solving processes	Classroom discussions were not yet fluent, with students showing passivity in their responses.	Students demonstrated active inquiry, responsive participation, and contributions to classroom discussions.

During the core learning activities, improvements in both teacher and student activities were observed across all learning phases from Cycle I to Cycle II. In the orientation phase, students who were initially confused began to ask questions actively and demonstrated a better understanding of the problems presented. During the organizing phase, students initially struggled to identify the given and required information accurately. In the investigation phase, there was a noticeable increase in collaboration and participation within group discussions. During the development and presentation phases, students showed growing confidence in presenting their discussion results to the class. In the evaluation phase, students became more active in providing feedback and expressing their opinions without being prompted. Overall, the implementation of differentiated instruction based on Problem-Based Learning (PBL) progressively enhanced students' engagement, understanding, and critical thinking skills. This improvement aligns with the instructional design, in which teachers provide opportunities for students to learn according to their level of readiness while acting as facilitators who guide the problem-solving process.

Table 3. Teacher and student activities in cycles I and II during the closing activities

Learning Activities	Analysis Results	
	Cycle I	Cycle II
Presenting learning conclusions	Students were passive in summarising the lesson content.	Students demonstrated active engagement and enthusiasm in articulating lesson conclusions.
Providing a formative test	Formative assessments were suboptimal due to limited time availability.	Formative assessments were conducted successfully, with students working autonomously.
Conducting reflection	Learning reflection had not yet been implemented effectively.	Learning reflection was implemented successfully
Providing homework assignments	The teacher assigned homework; however, certain students failed to complete and submit it.	Students demonstrated discipline by completing and submitting their homework assignments
Presenting the next session's content	The teacher introduced the content for the subsequent session.	The teacher delivered the content for the subsequent session as a follow-up to the previous session.

During the closing activities, improvements in both teacher and student activities were observed. In Cycle I, the researcher was unable to implement the reflection stage effectively due to time constraints, and not all students actively participated in summarising the learning outcomes. In Cycle II, the closing activities were carried out effectively. Students actively participated in summarising the learning outcomes with the researcher and provided improved feedback on the learning process. The researcher also provided reinforcement and follow-up actions as part of the reflective process.

Based on the activities described in the implementation of Cycle I and Cycle II, the learning process showed continuous improvement. The shortcomings identified gradually decreased, resulting in a more effective learning process by the end of Cycle II. The analysis of the instructional steps in both cycles indicates a clear improvement in the learning process in Class IX. A of SMP Negeri 2 Kampar Kiri Hilir during the odd semester of the 2025/2026 academic year.

Analysis of Mathematical Learning Outcomes

Students' learning outcomes were analysed using the Kriteria Ketercapaian Tujuan Pembelajaran (KKTP) set by the school, with a minimum score of 75. The percentage of students achieving the KKTP in mathematics before and after the intervention is presented in Table 4.

Table 4. Percentage of students achieving KKTP in mathematics before and after intervention

Learning Outcomes	Before Intervention	After Intervention	
	Baseline Score	Summative Assessment 1	Summative Assessment 2
Total number of Students who achieved KKTP (≥ 75)	7	8	12
Percentage of Students Who Achieved KKTP (%)	35%	40%	60%

Based on the analysis of students' mathematics learning outcomes, the frequency distribution shows an increase in achievement from the baseline score (before the action) to Cycle I and Cycle II. The data indicate that the percentage of students reaching the KKTP increased from 7 students (35%) at baseline to 8 students (40%) in Cycle I, and further to 12 students (60%) in Cycle II.

Differentiated instruction based on the PBL model in this study was found to improve students' learning outcomes, consistent with

previous research. Ismaimuza (2024) reported that implementing differentiated PBL learning increased the achievement of Grade VIII students at SMP Negeri 4 Palu, particularly in mathematics. Similarly, Cahyanti (2024) concluded that differentiated instruction within a PBL framework effectively enhanced students' activeness and learning outcomes.

The research findings demonstrate that implementing differentiated instruction based on the Problem-Based Learning (PBL) model successfully improved the learning process and enhanced mathematics achievement among Grade IX students. A student at SMP Negeri 2 Kampar Kiri Hilir. This improvement is evident from the increased teacher and student activities across cycles and the higher percentage of students meeting the Kriteria Ketercapaian Tujuan Pembelajaran (KKTP)

The enhanced quality of the learning process stems from differentiated instruction, which enables students to learn according to their individual readiness levels. Grouping students by readiness allows teachers to provide more targeted guidance: lower-ability students receive intensive support, while higher-ability students face challenges that foster critical thinking. This aligns with Tomlinson & Imbeau (2014), who argue that differentiated instruction addresses learner needs by adapting the instructional process to boost engagement.

Additionally, the PBL model encouraged students to actively identify problems, engage in discussions, and develop solutions independently or collaboratively. These activities shifted learning from teacher-centred to student-centred approaches. This finding supports Khofshoh, Rasiman, & Rifai (2023), who found that PBL increases student activity and problem-solving abilities through direct involvement in contextual problem-solving.

Mathematics achievement improved, with the percentage of students achieving KKTP rising from 35% at baseline to 40% in Cycle I and 60% in Cycle II. This indicates that differentiated PBL effectively helped students grasp Systems of Linear Equations in Two Variables (SLETV). Herwina (2021) similarly noted that readiness-based differentiation optimally supports students in meeting learning objectives.

This study also supports earlier research. Arisandi (2024) concluded that PBL-based differentiated instruction increased student activity and learning objective mastery. Widana & Kusuma (2023) found that PBL combined with differentiated instruction significantly improved mean scores and mastery levels. Likewise, Wati & Dewi (2023) reported that differentiated PBL enhanced students' conceptual understanding and mathematics achievement.

The use of contextual problems in PBL helped students relate mathematical concepts to real-life situations, making their understanding more meaningful. Students did not merely memorise procedures but also comprehended concepts and applied them in various contexts. Sakti & Luthfiyah (2024) also noted that integrating differentiated instruction with PBL creates a learning environment that is responsive to differences in student ability and has a positive impact on learning outcomes.

IV. Conclusion

The findings of this study on the implementation of Differentiated Instruction based on the Problem-Based Learning (PBL) model in class IX. A study of SMP Negeri 2 Kampar Kiri Hilir indicates that this approach successfully improved the mathematics learning process. This is reflected in the increased active participation of students in discussions, problem solving, and overall engagement during mathematics lessons. The learning process became more effective, and students were more encouraged to think critically and creatively when dealing with mathematical problems.

The application of Differentiated Instruction based on PBL also proved effective in improving the mathematics learning outcomes of Grade IX. A student at SMP Negeri 2 Kampar Kiri Hilir. This improvement is evident in post-intervention evaluation results, which show an increase in the class average score and a higher

percentage of students achieving mastery compared to the period before PBL was implemented. These findings are consistent with previous research demonstrating that integrating differentiated learning with PBL can significantly enhance student engagement and achievement in mathematics

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