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Improving vocational students' learning outcomes through problem-based learning with multimodal learning media

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ABSTRACT

Learning in vocational schools, particularly in database subjects, is still hampered by conventional methods that do not develop critical thinking skills and practical applications that meet industry needs. This study aims to assess the effect of using learning media in implementing the Problem-Based Learning (PBL) model on improving vocational students' learning outcomes, particularly in database materials. The research employed a three-cycle Classroom Action Research (CAR) method, conducted with 32 students of class XI RPL at SMKN 13 Bandung. The learning strategy in this study was designed using a PBL approach and integrated multimodal media, including PDF modules, PowerPoint presentations, and learning videos. The results showed a significant and consistent increase in student learning outcomes, with the average score rising from 66.30 in the first cycle to 81.84 in the third cycle. This finding confirms that the use of varied learning media in PBL can enhance conceptual understanding and increase students' active engagement in learning.

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ABSTRAK

Pembelajaran di SMK, khususnya pada mata pelajaran basis data masih terkendala oleh metode konvensional yang kurang mengembangkan keterampilan berpikir kritis dan penerapan praktis sesuai kebutuhan industri. Penelitian ini bertujuan untuk mengukur pengaruh penggunaan media pembelajaran dalam penerapan model Problem-Based Learning (PBL) terhadap peningkatan hasil belajar siswa SMK, khususnya pada materi basis data. Metode penelitian yang digunakan adalah Penelitian Tindakan Kelas (PTK) tiga siklus, yang dilaksanakan terhadap 32 siswa kelas XI RPL di SMKN 13 Bandung. Strategi pembelajaran dalam penelitian ini dirancang dengan pendekatan PBL yang diintegrasikan dengan media pembelajaran multimoda yang terdiri dari modul PDF, presentasi PowerPoint, dan video pembelajaran. Hasil penelitian menunjukkan peningkatan hasil belajar siswa yang signifikan dan stabil, dengan skor rata-rata meningkat dari 66,30 pada siklus I menjadi 81,84 pada siklus III. Temuan ini menegaskan bahwa penggunaan media pembelajaran yang bervariasi dalam konteks PBL dapat mendorong pemahaman konseptual yang lebih baik dan meningkatkan keterlibatan aktif siswa dalam pembelajaran.

Kata Kunci: *media pembelajaran; pembelajaran berbasis masalah; sekolah menengah kejuruan*

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INTRODUCTION

Amid rapid technological advancement and evolving workforce demands, the relevance and quality of vocational education have become increasingly critical. Vocational education plays a strategic role in preparing competent and adaptive human resources for the increasingly complex dynamics of the world of work (Hastutiningsih et al., 2024). In the digital era and within Industry 4.0, vocational education faces the challenge of integrating theoretical competencies with practical skills aligned with industry needs (see: https://www.weforum.org/publications/the-future-of-jobs-report-2020/). In the field of information technology, Vocational High School (Sekolah Menengah Kejuruan or SMK) students majoring in Software Engineering are required to master various technical competencies, including database management, which provides an essential foundation for information system development. The effectiveness of learning in vocational education depends heavily on educators' ability to design learning strategies that emphasize not only knowledge transfer but also the development of critical thinking skills and applicable problem-solving abilities (López et al., 2023; Xu et al., 2023).

This is increasingly important given the characteristics of vocational learning, which emphasizes practical and contextual aspects related to the world of work (Ismail et al., 2025; Parker & Roumell, 2020). In real-world settings, vocational high school students must study several complex subjects, including databases. Database teaching at the vocational high school level faces various challenges, including the complexity of the material, which requires a strong conceptual understanding and practical implementation skills. Initial observations indicate that the conventional learning methods still predominantly used have not optimized student learning outcomes, particularly in developing analytical skills and applying database concepts in real-world contexts. Furthermore, the heterogeneity of student learning styles and the demands of a competency-oriented curriculum require a diversified learning approach that is more adaptive and responsive to individual student needs. This situation involves innovation in learning strategies that accommodate diverse student learning modalities while remaining aligned with industry needs.

Recent research shows that Problem-Based Learning (PBL) has been proven effective in improving various aspects of learning, including conceptual understanding (Ariani, 2024; Oktaviani et al., 2024), critical thinking skills (Jumhur et al., 2024; Suryani et al., 2024), communication skills (Maksum et al., 2024), and problem-solving skills at various levels of education (Siregar & Siregar, 2025). PBL consistently has a positive impact on learning achievement compared to traditional learning methods (Hursen, 2021; Nantha et al., 2022). Meanwhile, the integration of multimedia technology into learning has shown significant potential to improve learning effectiveness. The combination of visual and auditory modalities can optimize students' cognitive processes (Agustina et al., 2024; Kurdekar & Sushma, 2020). Other studies confirm that the appropriate use of multimedia can improve information retention compared to solely text-based learning (Alhazmi, 2024). Previous studies such as those have shown that the use of multimedia in the learning process can significantly improve information retention, facilitate knowledge transfer, and boost students' learning motivation

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(Awogbami, 2020; Husaeni et al., 2022; Li & Liu, 2024; Wu, 2024; Ridayani & Purwanto, 2024; Zafrullah et al., 2024).

Although numerous studies have examined the effectiveness of PBL and multimedia separately, there is a significant research gap in the systematic integration of these two approaches, particularly in the context of database learning in vocational education. Most previous studies are descriptive or focus on a single type of learning medium, without conducting a comprehensive comparative analysis (Wu, 2024). More specifically, no research has empirically examined differences in the effectiveness of various learning media (PDF modules, PowerPoint presentations, and learning videos) when integrated with PBL models in database learning in vocational high schools. This gap is crucial given the unique characteristics of vocational learning, which requires a balance between theoretical understanding and practical application. Furthermore, previous studies generally employ simple experimental designs or single-case studies, thereby failing to provide an in-depth knowledge of the processes and mechanisms by which learning outcomes are improved through the integration of PBL and multimedia in the context of continuous, cyclical learning.

Based on the background and gaps, this study examines how the use of various learning media (PDF modules, PowerPoint presentations, and learning videos) in implementing the PBL model affects vocational students' learning outcomes in database materials. The main objective of this study is to determine the extent to which integrating learning media within the PBL framework can significantly and sustainably improve student learning outcomes. The findings are expected to provide theoretical contributions to the development of more effective, contextually informed vocational learning strategies, while also offering practical implications for educators in designing learning that is adaptive to students' needs and characteristics. The novelty of this study lies in the simultaneous integration of multimodal learning media with PBL, as well as in the analysis of differences in effects across media through a cyclical classroom action approach oriented toward systematically improving learning outcomes.

LITERATURE REVIEW

Problem-Based Learning (PBL)

Problem-Based Learning (PBL) is a student-centered learning model that presents authentic problems for students to study and solve independently or collaboratively (Andayani & Gunawan, 2025; Ni'mah et al., 2024). In the process, students learn to identify problems, organize information, analyze data, and develop evidence-based solutions, while the teacher acts as a facilitator. Several key features characterize this model: learning begins with the presentation of contextual problems relevant to real life, involves small-group collaboration, focuses on interdisciplinary connections, and produces a product or work that demonstrates student understanding (Mishra, 2023).

The implementation stages of PBL generally consist of five steps: 1) Orienting students to the problem; 2) Organizing investigative activities; 3) Conducting independent and group investigations; 4) Developing and presenting results; and 5) Analyzing and evaluating the problem-solving process (Sari et al., 2021). PBL has several advantages, including improving conceptual understanding, encouraging learning activities and motivation, fostering critical

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and creative thinking skills, and linking learning to real-world contexts (Arsyad et al., 2024; Hafizah et al., 2024). However, its implementation also has limitations, including the need for substantial time, high levels of teacher and student readiness, and the risk of reduced interest in learning if students do not understand the problem's relevance. Overall, PBL is considered an effective approach to fostering meaningful, contextual learning while developing 21st-century skills, including collaboration, problem-solving, and critical thinking, in vocational education.

Learning with a Differentiated Approach

Differentiated learning is an approach developed by Carol Ann Tomlinson to adapt instruction to students' individual needs, interests, and learning styles (Diananseri & Yaslina, 2024; Tomlinson et al., 2003). This approach emphasizes the importance of balancing students' learning readiness with teacher-designed instructional strategies to enable each student to reach their full potential (Fitriani et al., 2025). Effective implementation requires a positive learning environment, a meaningful curriculum, ongoing assessment, and flexible classroom management (Rosyid et al., 2023).

There are four main aspects of differentiation (Melesse & Belay, 2022). The first is content differentiation, which concerns the material or competencies that students must master. In the content aspect, teachers adjust the depth and methods of instruction to students' learning readiness, considering the levels of Bloom's Taxonomy. The second refers to how students understand and process information. Process differentiation is achieved by adapting to visual, auditory, and kinesthetic learning styles through a variety of flexible learning activities. The third aspect is Product Differentiation, a learning outcome that demonstrates students' understanding of the material. This can take the form of reports, projects, presentations, or creative work tailored to individual learning styles. Fourth is the Differentiated Learning Environment. This aspect encompasses the physical and psychological aspects of a classroom that is flexible, safe, and supportive of collaboration and independent learning.

Assessment in Differentiated Learning is conducted continuously through three main stages: 1) Diagnostic (pre-assessment) to map student readiness and needs; 2) Formative to monitor learning progress; and 3) Summative, which allows for various forms of expression of learning outcomes according to student needs and styles (Rahmadewi et al., 2025; Wati et al., 2025). This approach has several advantages, including improving academic achievement, motivation, engagement, and student independence, as well as creating an inclusive learning environment that values diversity. However, challenges include the need for extensive planning, intensive teacher training, and the complexity of individual assessments. Overall, Differentiated Learning is an adaptive, learner-centered strategy designed to accommodate individual differences to achieve optimal learning outcomes (Adithya et al., 2025; Saputra et al., 2025). This approach is relevant to vocational education because it adapts instruction to students' varying levels of readiness and learning styles, thereby increasing its effectiveness and alignment with workplace needs.

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METHODS

This study adapted a three-cycle Classroom Action Research (CAR) approach to analyze the effect of using learning media in implementing PBL on improving vocational students' learning outcomes in database subjects. The study participants were 32 students from class XI RPL 2 at SMKN 13 Bandung. The roles of each in the study were: teachers as facilitators, students as active participants in study groups, and observers as recorders of the implementation of learning strategies and group dynamics. Each cycle was conducted in a single 5 × 45-minute meeting, comprising four stages: planning, implementation, observation, and reflection. The study took place on February 26, March 12, and April 09, 2025. **Figure 1** shows the stages of the research that have been carried out and the action plan that will be carried out in the proposed period.

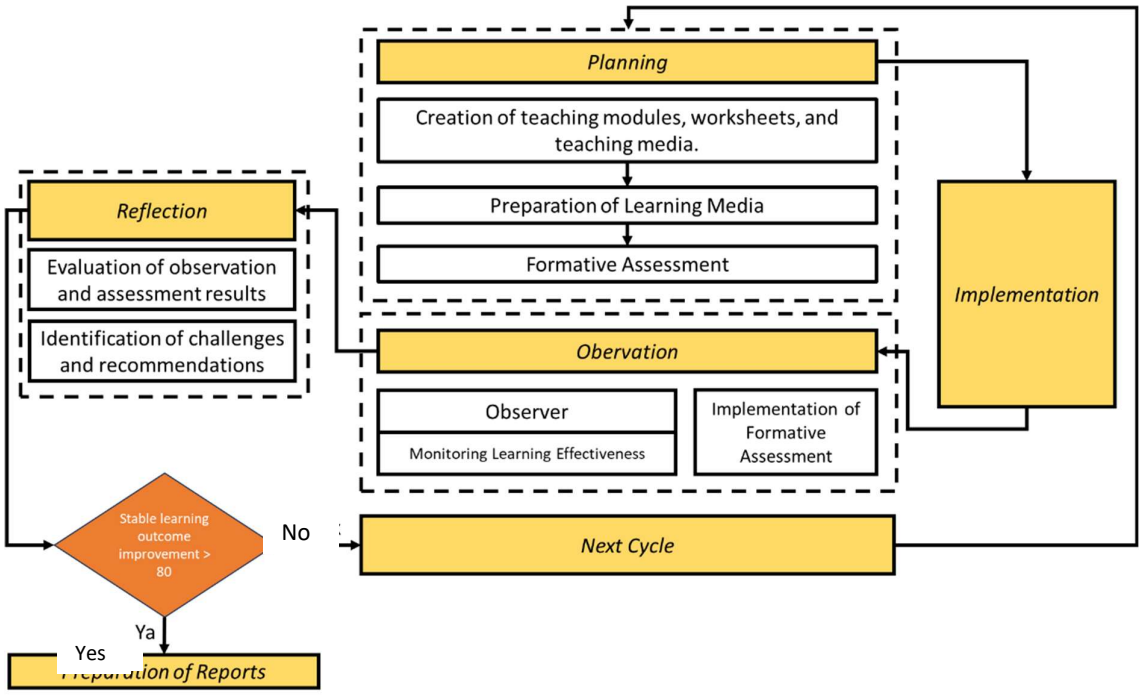

Figure 1. Research Flow Diagram
Source: Author's Documentation 2025

As shown in Figure 1, this classroom action research procedure is implemented through several cyclical stages, from planning through reporting, which are systematically interconnected to ensure continuous improvement in the learning process. The first stage in classroom action research is planning. At this stage, we develop a learning plan using a PBL strategy, combined with a differentiated approach to tailor instruction to students' characteristics and needs. Planning includes selecting and organizing materials, learning methods, and media, and evaluating the tools used to measure student achievement. Furthermore, observation instruments are prepared to enable observers to record the learning process objectively. With careful planning, the learning process will proceed systematically and support the achievement of the research objectives.

The second stage is implementation, in which the developed plan is directly applied to classroom teaching and learning activities. The teacher acts as a facilitator, guiding students

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through problem-based activities in accordance with PBL principles. Students are encouraged to explore real-life problems, discuss them, work collaboratively in groups, and utilize prepared learning media. A differentiated approach is implemented to ensure that each student can actively participate in accordance with their individual ability level and learning style. This stage is the core of the cycle because the designed strategies are directly tested in learning practice.

The next stage is observation, in which observers record the learning process across various learning media using a differentiation-based scaffolding method. Observations are conducted to obtain empirical data regarding student engagement, the effectiveness of the differentiated PBL method, and any obstacles that arise during the activity. Observers assess how students respond to the problems presented, how actively they participate in discussions, and how media use supports understanding of the material. These observational data will serve as a basis for assessing the effectiveness of the actions and determining corrective measures for the next cycle.

The reflection stage is the process of critically analyzing the results of observations and the implementation of actions. In this stage, we, along with observers, evaluate the extent to which the differentiated PBL strategy has improved student engagement and learning outcomes. Reflection includes identifying successes, weaknesses, and obstacles that emerged during the learning process. Based on the reflection, we can assess the effectiveness of the actions and develop a more appropriate improvement plan for the next cycle. Thus, reflection serves as a bridge between one cycle and the next, fostering continuous improvement.

After reflection, we check whether the success indicators have been achieved. The indicator used in this research is when student learning outcomes show stable improvement with an average score of over 80. If this indicator is met, the cycle is terminated, as the action is deemed successful in achieving the research objectives. However, if the learning outcomes do not meet the established standards, the research proceeds to the next cycle, refining the action plan based on the reflection results. Thus, this research is cyclical and flexible, adapting to the need for improvement until the objectives are achieved. If the success indicator is not completed, the research continues to the next cycle.

The planning, implementation, observation, and reflection process is repeated, with adjustments to the learning strategy based on weaknesses identified in the previous cycle. Each cycle will bring significant improvements to the learning process and outcomes. The cycle can be repeated until the research achieves the desired results, namely, consistent improvement in student learning outcomes. The final stage in classroom action research is the preparation of a research report. After the cycle concludes and the success indicator is achieved, the entire process, from planning to reflection, is documented in a scientific report. This report presents the research background, the action design implemented in each cycle, observational results, reflective analysis, data on improvements in learning outcomes, and conclusions regarding the effectiveness of the differentiated PBL strategy employed.

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RESULTS AND DISCUSSION

Stages of the Learning Cycle

Cycle 1 implements PBL with Single Row Subquery material. The learning media available are limited to PDF-format learning modules. Students are given exploratory case studies in groups, presented in the Student Worksheet PDF shown in **Figure 2**. Students are also provided with module-based study materials for solving problems, as shown in Figure 3, without the use of visual/audio media. Observations are conducted to identify limitations in conceptual understanding and group interaction.

Figure 2. Cycle 1 Student Worksheet
Source: Author's Documentation 2025

Figure 2 shows the Student Worksheet designed for the Single Row Subquery material. This student worksheet serves as a guide for PBL learning activities. It includes student identity, learning objectives, achievement indicators, brief material descriptions, and case studies that students must complete in groups. This student worksheet provides exploratory guidance, encouraging students to connect theoretical concepts with hands-on practice through solving real-life cases in a database. In theory, the use of the student worksheet serves as a stimulus and guide for learning activities, enabling students to construct their knowledge actively. Furthermore, the student worksheet supports Piaget's constructivist theory, in which students build concepts through interactions with challenging tasks. Therefore, the student worksheet in this study was designed to facilitate independent learning, group collaboration, and real-world problem solving.

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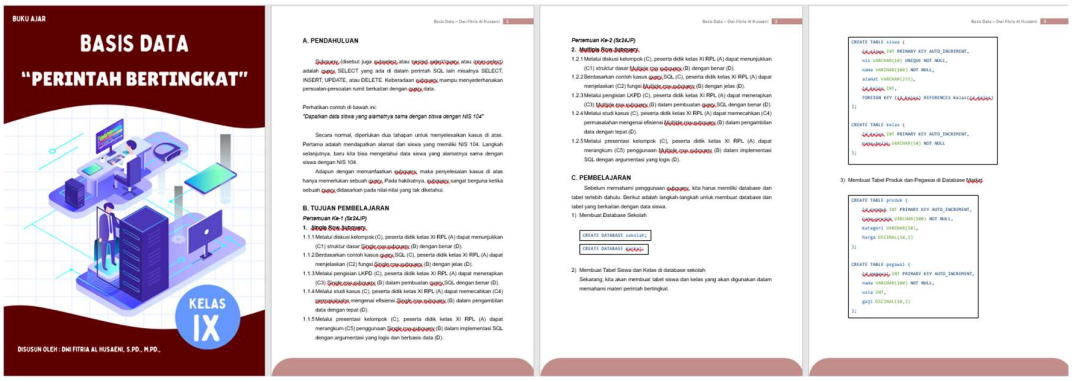

Figure 3. Cycle 1 PDF Textbook
Source: Author's Documentation 2025

Figure 3 shows a teaching module in e-book (PDF) format used for student self-study. This module includes descriptions of theoretical concepts, examples of SQL subquery syntax, and practice questions that can be completed individually. The module format remains simple, consisting solely of text and SQL code, without interactive visual or audio elements. This observation is that limited media makes it less effective for students to understand abstract SQL concepts, especially in nested queries that require visualizing data structures. The use of teaching modules is an essential part of instructional materials that must align with learning objectives and assessments (Ajid et al., 2025; Calamlam, 2021; Maulisa et al., 2024). In addition, the module supports the theory of independent learning, enabling students to learn independently through systematic learning resources (Rufii, 2015). However, because it is text-based only, this module does not fully adhere to the principle of Dual Coding Theory, which posits that understanding is improved when information is presented in both verbal and visual forms (Alhazmi, 2024; Kurdekar & Sushma, 2020; Qasserras, 2024).

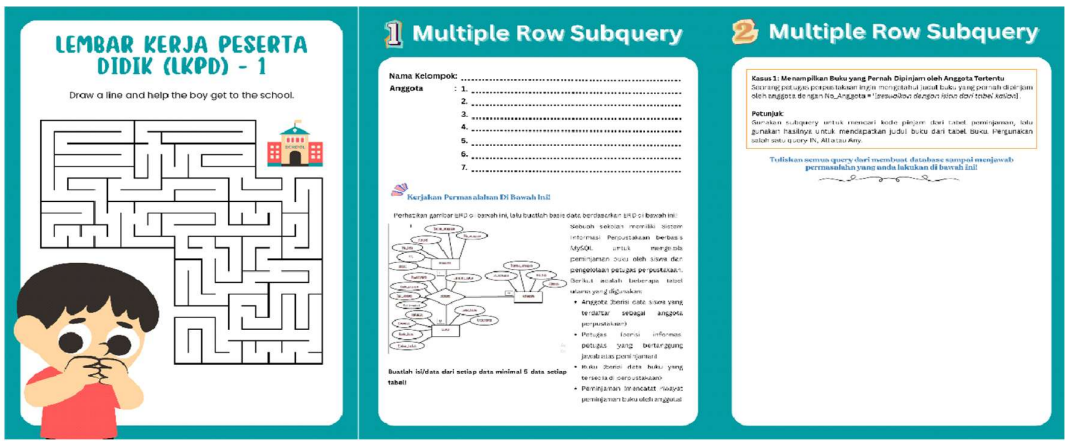

Figure 4. Cycle 2 Student Worksheet
Source: Author's Documentation 2025

Cycle 2 builds on the first cycle, focusing on Multiple Row Subquery material. The implementation of this cycle is based on the results of reflection from the previous cycle, which showed that the learning media used remained monotonous and less effective at

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engaging students' interest. In response to these findings, the teacher implemented a differentiated approach by providing a variety of learning media, namely PDF modules, PowerPoint presentations (PPT), and videos. During instruction, students work in groups to complete SQL-based case studies, with an emphasis on applying concepts and collaborating among group members. In addition, in cycle 2, the student worksheet is made as attractive as possible through the use of images and colors, and the first page includes games; each group completes a different case. **Figure 4** shows the student worksheet used in cycle 2.

Figure 5. Cycle 2 learning media: (a) PDF textbook; (b) PPT; (c) learning video
Source: https://www.youtube.com/watch?v=4fXp9qMxkR 2025

Figure 5 shows the learning media used in cycle 2. Furthermore, cycle 3 refines the previous implementation, with a focus on the JOIN Table material. Based on the second-cycle reflection, the learning media comprising PDF modules, PowerPoint presentations (PPT), and learning videos were considered effective in improving student learning outcomes (the average score reached 80), as explained in greater detail in the results and discussion section. Therefore, in the third cycle, no new media types were added; the combination of PDF, PPT, and video was retained to maintain consistency in achievement and to assess the stability of learning outcome improvements. Improvements made in this cycle focused on non-media aspects, namely the quality of the student worksheet and teacher guidance patterns.

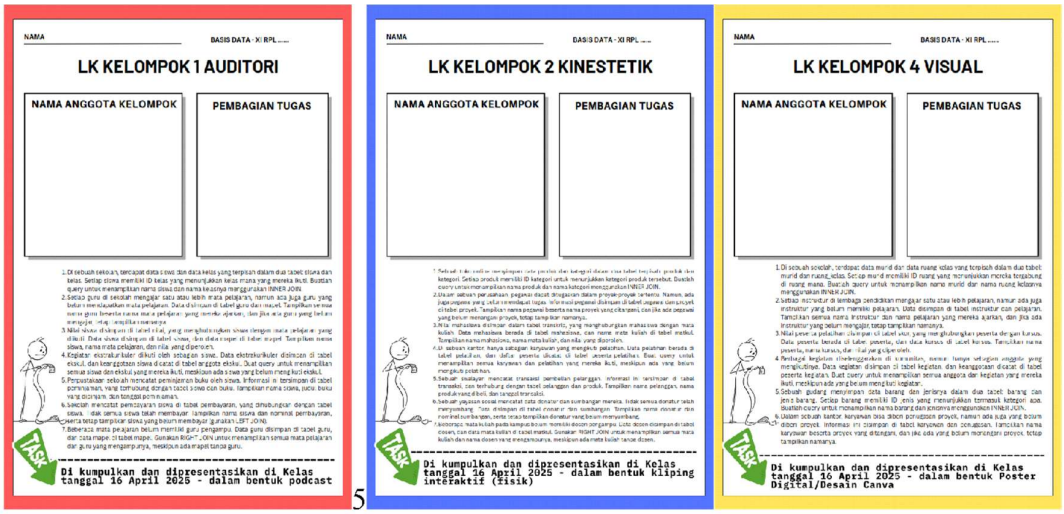

Figure 6. Cycle 3 Student Worksheet
Source: Author's Documentation 2025

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The student worksheet was redesigned to be more exploratory, encouraging students to explore concepts through more challenging and collaborative activities. In addition, significant changes were made to teachers' roles in the learning process. Teachers provide more intensive guidance by accompanying students in groups or one-on-one to ensure that each group receives appropriate direction and support to complete problem-solving tasks. This approach is intended to strengthen active involvement, improve conceptual understanding, and maintain the learning outcomes achieved in the previous cycle. **Figure 6** shows the student worksheet in cycle 3.

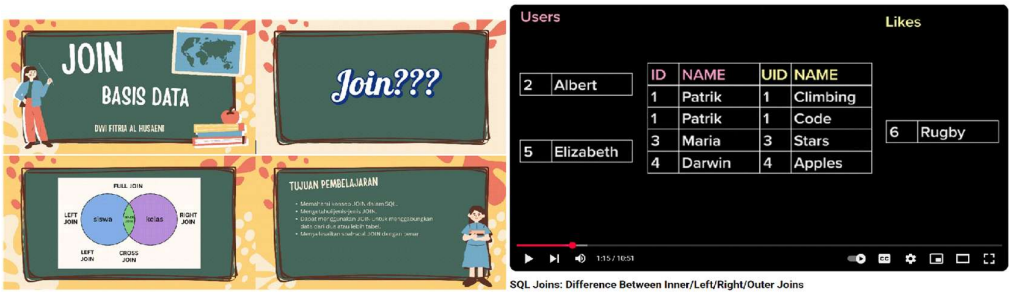

Figure 7. Cycle 3 Learning Media
Source: https://www.youtube.com/watch?v=zGSv0VaOtR0 2025

Figure 7 depicts the learning media, which feature engaging displays and animations that facilitate students' understanding of the material in Cycle 3.

Learning Outcomes

The study results showed an increase in the learning outcomes of vocational students in database subjects through the implementation of PBL supported by multimedia. This increase is evident in the average student score, which rose from 66.30 in the first cycle to 80.00 in the second and then to 81.84 in the third, as shown in **Figure 8**.

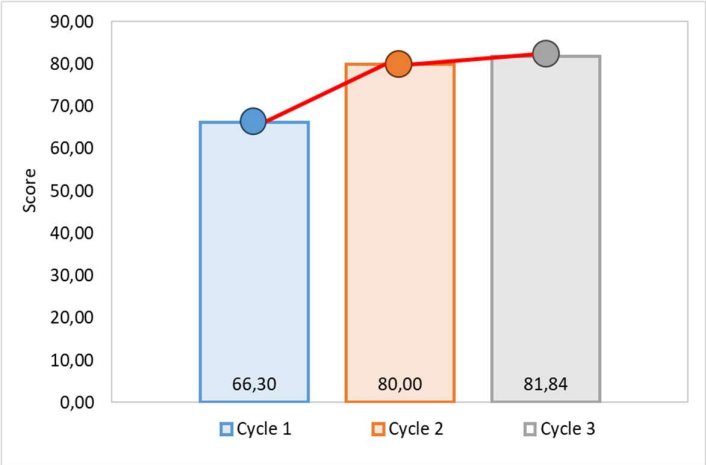

Figure 8. Results of Three Learning Cycles
Source: Author's Documentation 2025

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Figure 8 shows a stable upward trend and indicates that the gradually implemented intervention addressed the learning problems identified from the outset.

Discussion

Theoretically, the PBL learning model is designed to improve students' critical thinking and problem-solving skills through real situations that require active involvement in the learning process (Andayani & Gunawan, 2025; Jumhur et al., 2024; Kek & Huijser, 2011; Maksum et al., 2024; Razak et al., 2022; Suryani et al., 2024). PBL places students as the subject of learning and emphasizes the process of constructing knowledge through group work, investigation, and reflection (Mishra, 2023). In this context, students complete SQL-based case studies relevant to their expertise, thereby creating contextual and meaningful learning. This supports research findings that PBL is effectively applied in vocational education, as it prepares students to address real-world workplace challenges (Husaeni et al., 2023; Arsyad et al., 2024; Hafizah et al., 2024; Jabarullah & Hussain, 2019). In addition, improvements in learning outcomes are inseparable from the use of multimedia learning, which supports the principle of multimodal learning.

In the first cycle, the learning media consisted only of a PDF module, which did not sufficiently support visual or auditory learning styles. Following the addition of media, including PowerPoint presentations and learning videos, in the second and third cycles, there was a sharp increase in students' understanding of SQL concepts. This aligns with Mayer's Cognitive Theory of Multimedia Learning, which posits that learning is more effective when information is presented through a combination of verbal (text/narration) and visual (images/animation) elements (Agustina et al., 2024; Basyaev et al., 2021). The results of this study also align with several previous studies that have shown significant potential for enhancing learning effectiveness, starting with optimizing students' cognitive processes (Kurdekar & Sushma, 2020), improve information retention (Alhazmi, 2024), as well as significantly improve information retention, facilitate knowledge transfer, and increase student learning motivation (Husaeni et al., 2023; Awogbami, 2020; Husaeni et al., 2022; Li & Liu, 2024; Ridayani & Purwanto, 2024; Wu, 2024; Zafrullah et al., 2024).

Well-designed learning media can reduce cognitive load and increase knowledge retention. In this study, learning videos play an essential role in simplifying abstract concepts into more concrete and understandable ones. For example, the visual representation of the JOIN operation between tables in SQL makes it easier for students to understand how relationships among data are formed in practice. Meanwhile, the PowerPoint presentation helps organize the flow of information systematically, which is essential for explaining the complex structure of SQL commands. The combination of the three (PDF, PPT, and video) provides a holistic learning experience that can be tailored to students' individual learning styles. Differentiation strategies also make an essential contribution to improving learning outcomes. In this approach, teachers not only deliver material in one direction, but also provide students with the freedom to express their understanding through final products that suit their preferences and abilities. Tomlinson emphasized that differentiated learning enables students to achieve the same learning goals through different pathways, taking into account each individual's learning readiness, interests, and learning profile (Diananseri & Yaslina, 2024; Goyibova et

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al., 2025; Tomlinson et al., 2003). By implementing product differentiation, students feel more appreciated, more motivated, and more active in learning.

Furthermore, previous research has shown that differentiated learning is an approach that can adapt the learning process to the needs, interests, and learning styles of individual students (Diananseri & Yaslina, 2024). This approach emphasizes the importance of balancing students' learning readiness with teacher-designed instructional strategies to enable each student to reach their full potential (Fitriani et al., 2025). Effective implementation requires a positive learning environment, a meaningful curriculum, continuous assessment, and flexible classroom management (Rosyid et al., 2023). Therefore, this approach is relevant to vocational education because it adapts instruction to students' readiness levels and learning styles, thereby increasing its effectiveness and alignment with workplace needs. The effectiveness of learning in vocational education depends heavily on educators' ability to design learning strategies that emphasize not only knowledge transfer but also the development of critical thinking skills and applicable problem-solving abilities (López et al., 2023; Xu et al., 2023). The role of teachers also improved from cycle to cycle.

In the third cycle, teachers provided intensive one-on-one guidance to groups of students, which had a positive effect on conceptual understanding and group dynamics. This reflects the application of Vygotsky's scaffolding principle, in which teachers serve as guides to help students complete tasks within their zone of proximal development (Xi & Lantolf, 2021). More personal interactions between teachers and groups of students help create a supportive and productive learning environment. By maintaining the media combination that was effective in the second cycle and focusing on improving the quality of student worksheets and teacher guidance strategies, the third cycle demonstrates that consistent improvements in learning outcomes are achievable. This indicates that the stability of learning outcomes can be maintained if adaptive learning strategies are applied consistently. Overall, PBL, when integrated with multimedia and differentiation, has been shown to improve vocational students' learning outcomes. Learning becomes more meaningful, contextual, and aligned with students' needs. This study provides empirical evidence that a learning designs that consider variations in learning styles and the use of technology can optimize students' understanding of complex materials, such as SQL in databases.

CONCLUSION

Based on the study results, the use of learning media in implementing Problem-Based Learning (PBL) effectively improves the learning outcomes of vocational students in database subjects. The integration of media, such as PDF modules, PowerPoint presentations, and learning videos, enhances the interactive learning experience. It aligns with diverse student learning styles, thereby encouraging deeper conceptual understanding and more active collaboration. The increase in learning outcome scores from 66.30 in the first cycle to 81.84 in the third cycle indicates a positive stability in learning achievement. The differentiation strategy in PBL and the active role of teachers in guiding groups intensively also strengthen the effectiveness of learning. These findings confirm that PBL, supported by appropriate media and adaptive approaches, can be a strategic solution for improving the quality of

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vocational learning and for providing new directions for teachers and researchers in designing learning interventions that are more contextual, sustainable, and responsive to student needs. However, these findings should be interpreted with several limitations in mind. This study was conducted in a single school without a control group, with a relatively short cycle duration and a predominantly cognitive assessment focus. Other variables, such as initial abilities, device/network access, and student profiles, were not analyzed. Given these limitations, further research is recommended to extend the context to additional schools and to employ a quasi-experimental design with a comparison group.

AUTHOR'S NOTE

The author declares that there is no conflict of interest regarding the publication of this article. The author confirms that the article's data and content are free of plagiarism.

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