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ORIGINAL RESEARCH ARTICLE

Implementing Problem-Based Learning to Improve Vocational High School Students' Learning Outcomes in Occupational Health and Safety

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ABSTRACT

Occupational Health and Safety (OHS) instruction in vocational high schools needs to help students understand concepts while also reasoning about their application in work situations. This classroom action research aimed to describe the implementation of the Problem-Based Learning (PBL) model and the change in OHS learning mastery among Grade XII Light Vehicle Engineering students at SMK Utama Kepanjen, Malang Regency. The study was conducted in two cycles, each planned to consist of two meetings, through the stages of planning, action, observation, and reflection. Learning used contextual problems concerning workplace hazards, personal protective equipment, accident prevention, safety procedures, and OHS culture. Students worked in groups to identify problems, search for information, formulate solutions, present their results, and take an evaluation using Quizizz, as described in the lesson materials. Learning outcome data were summarized by score category and the minimum mastery criterion (KKM) of 75. At baseline, 8 of 32 students (25.00%) reached the KKM. After Cycle I, the number of students reaching the KKM rose to 22 (68.75%), and after Cycle II it increased to 31 (96.88%). Thus, mastery increased by 43.75 percentage points from baseline to Cycle I and by 28.13 percentage points from Cycle I to Cycle II. These findings indicate that the implementation of PBL in the classroom studied was followed by an increase in learning mastery. Because the study did not use a comparison group and combined several learning elements, the findings cannot be used to isolate the effect of PBL from other factors or to infer broad cause-and-effect relationships. The study provides contextual evidence for vocational teachers to develop problem-based OHS instruction accompanied by discussion, presentation, evaluation, and reflection.

Keywords: learning outcomes; occupational health and safety; classroom action research; vocational education; Problem-Based Learning

ABSTRAK

Pembelajaran Kesehatan dan Keselamatan Kerja (K3) di sekolah menengah kejuruan perlu membantu siswa memahami konsep sekaligus menalar penerapannya pada situasi kerja. Penelitian tindakan kelas ini bertujuan mendeskripsikan penerapan model Problem-Based Learning (PBL) dan perubahan ketuntasan hasil belajar K3 pada siswa kelas XII Teknik Kendaraan Ringan di SMK Utama Kepanjen, Kabupaten Malang. Penelitian dilaksanakan dalam dua siklus, masing-masing direncanakan terdiri atas dua pertemuan, melalui tahap perencanaan, tindakan, observasi, dan refleksi. Pembelajaran menggunakan masalah kontekstual tentang bahaya kerja, alat pelindung diri, pencegahan kecelakaan, prosedur keselamatan, dan budaya K3. Siswa bekerja dalam kelompok untuk mengidentifikasi masalah, mencari informasi, merumuskan solusi, mempresentasikan hasil, dan mengikuti evaluasi menggunakan Quizizz sebagaimana dideskripsikan dalam perangkat pembelajaran. Data hasil belajar diringkas berdasarkan kategori nilai dan kriteria ketuntasan minimal (KKM) 75. Pada kondisi awal, 8 dari 32 siswa (25,00%) mencapai KKM. Setelah siklus I, jumlah siswa yang mencapai KKM menjadi 22 orang (68,75%), sedangkan setelah siklus II meningkat menjadi 31 orang (96,88%). Dengan demikian, ketuntasan meningkat 43,75 poin persentase dari kondisi awal ke siklus I dan 28,13 poin persentase dari siklus I ke siklus II. Temuan ini menunjukkan bahwa pelaksanaan PBL dalam konteks kelas yang diteliti diikuti oleh peningkatan ketuntasan hasil belajar. Karena penelitian tidak menggunakan kelompok pembanding dan menggabungkan beberapa unsur pembelajaran, temuan tidak dapat digunakan untuk mengisolasi efek PBL dari faktor lain atau menyimpulkan hubungan sebab-akibat yang luas. Penelitian memberi bukti kontekstual bagi guru vokasi untuk mengembangkan pembelajaran K3 berbasis masalah yang disertai diskusi, presentasi, evaluasi, dan refleksi.

Kata Kunci: hasil belajar; kesehatan dan keselamatan kerja; penelitian tindakan kelas; pendidikan vokasi; Problem-Based Learning

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1. INTRODUCTION

Occupational Health and Safety (OHS) is an important competency in vocational education because students are being prepared to enter work environments involving diverse equipment, materials, procedures, and risks. In the Light Vehicle Engineering (TKR) program, understanding OHS is not only about being able to state rules but also about recognizing potential hazards, choosing preventive actions, using personal protective equipment (PPE) correctly, and considering the consequences of a decision. These competencies are relevant from the time students learn in the school workshop, because work habits formed during their education can become the basis of safety behavior when they undertake industrial internships or enter employment. Therefore, OHS instruction needs to provide learning experiences that connect concepts with situations students may encounter in the workplace.

This need presents a pedagogical challenge. Part of the OHS material consists of principles, terms, and procedures that are easy to teach through direct explanation. However, knowing the definition of a hazard is not necessarily the same as being able to analyze an incident, identify its causes, or determine preventive steps suited to a particular situation. If instruction mostly positions students as recipients of information, opportunities to test their reasoning and propose solutions may be limited. Problem-oriented learning can give students room to connect prior knowledge with new cases, construct explanations, compare alternatives, and justify their choices. In vocational

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education, this process is important because professional competence is demonstrated not only by mastery of declarative knowledge but also by the judgment used when facing work problems.

Baseline data on OHS learning in Grade XII TKR at SMK Utama Kepanjen, Malang Regency, showed that of the 32 students who took the initial evaluation, only 8 students, or 25%, reached the minimum mastery criterion (KKM) of 75. Twenty-four students, or 75%, had not yet reached this threshold. These data provided the contextual basis for improving instruction. Several possibilities, including student readiness, conceptual understanding, and accuracy in completing evaluations, may form the context of the problem, but they were not tested as separate variables and are therefore not treated as proven causal explanations.

One approach that can be used to respond to this need is Problem-Based Learning (PBL). PBL positions a problem as the starting point of the learning process. Students are directed to understand the problem, organize their work, conduct investigations, develop and present solutions, and evaluate the problem-solving process. In this model, the teacher does not disappear from the learning process but instead guides the investigation, maintains the focus of discussion, provides support when students encounter difficulties, and helps test the feasibility of solutions. With this structure, student activity is directed toward using knowledge rather than merely recalling information (Barrows, 1986; Hmelo-Silver, 2004; Savery, 2006; Dochy et al., 2003; Walker & Leary, 2009; Prince, 2004).

In the OHS context, authentic cases can be designed from situations such as workers not wearing PPE, accidents resulting from non-compliance with procedures, exposure to hazardous materials, or disorganized workplace conditions. Such cases give students the opportunity to identify facts, distinguish between hazards and risks, consider contributing factors, and then propose preventive measures. However, the use of contextual problems does not automatically guarantee effective learning. The quality of the problems, the division of roles within groups, the support of learning resources, time for investigation, and teacher feedback continue to influence the learning experience. PBL may also take longer than direct explanation, especially when students are not yet accustomed to discussing and constructing arguments (Hmelo-Silver, 2004; Savery, 2006; Koçoğlu & Kanadlı, 2025; Orhan, 2024).

Quizizz was used as a means of evaluation and reinforcement of learning. This digital quiz platform can present questions, display results, and provide feedback quickly. In the lesson design, Quizizz was placed in the evaluation component, while the core of PBL remained problem analysis, group investigation, presentation, and reflection. This distinction is conceptually important: a quiz platform is not a substitute for the PBL syntax and does not by itself make learning problem-based. Its function within the learning sequence is to help check understanding and provide information that teachers can use to respond to students' difficulties (Purba, 2020; Munawir & Hasbi, 2022; Zuhara et al., 2020; Musdalifah & Sunardjo, 2025; Jamilah et al., 2025; Mudzakir et al., 2026; Genza et al., 2026; Aprilia et al., 2025).

Although PBL and digital quizzes each have a pedagogical rationale, this classroom study is more appropriately read as an effort to improve instruction in one school context than as an experimental test of the effectiveness of a single component. There was no comparison group receiving different instruction, and the data presented consist mainly of the distribution of learning outcome categories at baseline, Cycle I, and Cycle II. Therefore, the questions that can be answered with the available evidence are how PBL instruction was implemented and how class mastery changed across the action cycles. The study cannot separate the contributions of PBL, Quizizz, repetition of material,

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teacher support, or other factors that may have occurred simultaneously (Freeman et al., 2014; Prince, 2004; Bai et al., 2020; Zainuddin et al., 2020; Sailer & Homner, 2020; Dichev & Dicheva, 2017; Dichev et al., 2020).

The relevant literature positions PBL as an approach with the potential to support engagement, problem-solving, and learning outcomes. For example, Yunansah et al. (2022) discussed the implementation of PBL in vocational high school instruction, while Rahman et al. (2023) reported a meta-analytic study of PBL in science learning. These sources provide a basis for considering PBL as a learning strategy, but they should not be treated as direct evidence that the same results will necessarily occur in all subjects or classes. Differences in fields, learner characteristics, materials, instruments, and implementation need to be considered when comparing research findings (Clark, 2012; Morris et al., 2021; Yuliani et al., 2026).

The research gap of this article is formulated in a limited and contextual manner. The study arose from the need to improve OHS mastery in one TKR class, while the action process was designed with cases related to workplace hazards, PPE, safety procedures, and OHS culture. This article does not claim that PBL has never been used in OHS instruction or that this study is the first of its kind. A more defensible contribution is to provide a description of the classroom action and the change in the distribution of mastery from baseline through two cycles in that school context, and to show the importance of reading the results alongside the limitations of the design and data reporting.

Accordingly, the objectives of this article are (1) to describe the implementation of PBL in OHS instruction in Grade XII TKR at SMK Utama Kepanjen; (2) to describe the change in learning mastery based on the KKM of 75 from baseline through Cycle I to Cycle II; and (3) to discuss the implications and limitations of the findings for OHS instructional practice in vocational education. These objectives are limited to the available evidence. The article does not claim that the change in mastery proves an improvement in practical OHS skills, long-term safety behavior, or a causal impact that can be generalized to other schools.

2. RESEARCH METHODS

This study employed a Classroom Action Research (CAR) approach. The actions were carried out in two cycles, and each cycle was planned to consist of two meetings. CAR was chosen to improve the classroom learning process through a sequence of planning, action, observation, and reflection. Within this framework, learning outcome data were used together with process observations to assess the progress of the actions and determine improvements for the next cycle. The study was not designed as a controlled experiment, so interpretation focuses on the changes observed during the classroom improvement process.

The research was conducted at SMK Utama Kepanjen in Malang Regency, East Java, with 32 Grade XII students in the Light Vehicle Engineering program as subjects. The baseline condition was identified through observation and learning evaluation. Individual student identities are not used in this article. Information on students' demographic characteristics, formal sampling techniques, and the distribution of initial ability other than learning outcome categories was not presented in full; therefore, the article does not add such details.

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The subject-matter focus was Occupational Health and Safety (OHS). The lesson materials covered basic OHS principles, hazard identification, use of PPE, accident prevention, safety procedures, and OHS culture. Example problems included accidents caused by workers not using PPE, exposure to hazardous gases due to the use of unsuitable masks, and accidents related to non-compliance with safety procedures. These cases were used to encourage students to analyze situations and formulate preventive steps.

The learning actions followed the PBL syntax. The first stage was orienting students to the problem: the teacher conveyed the learning objectives and presented a contextual problem, sometimes using a video or image as a stimulus. The second stage was organizing students for learning: students worked in groups, understood the task, and divided responsibilities. The third stage was independent or group investigation: students gathered information, discussed, analyzed the causes of the problem, and designed solutions under the teacher's guidance. The fourth stage was developing and presenting the results: groups presented their analysis and responded to other groups. The fifth stage was analyzing and evaluating the problem-solving process: the teacher and students reflected on the process, summarized the material, and reviewed the evaluation results.

Quizizz was used as part of the evaluation sequence. The quiz contained questions related to OHS material, including basic principles, hazard identification, and the use of PPE. Quiz results were described as a means of providing immediate feedback. However, the available information does not provide complete documentation of the number of items, the test blueprint, content validity, reliability, item difficulty, or item-level response data. Therefore, the article does not claim that the instrument underwent formal psychometric testing. Learning outcome scores are used as summarized in the research tables.

Each action cycle consisted of planning, action, observation, and reflection. In the planning stage, the researcher coordinated with the teacher, prepared the lesson plan, selected the material, prepared the Quizizz media, and developed the observation and evaluation sheets. In the action stage, learning was carried out following the PBL design. In the observation stage, the observer recorded teacher activities and student engagement. In the reflection stage, the implementation of learning was reviewed to determine what needed improvement. The observation details in the appendix show the use of checklists for teacher and student activities but do not present aggregate scores that would allow a quantitative comparison of implementation levels between cycles. Therefore, observations were used descriptively, not as a statistical measure of implementation effectiveness.

The main quantitative data were the frequencies of students in four score categories: 91–100 (very good), 81–90 (good), 75–80 (fairly good), and below 75 (not meeting the KKM). The KKM used was 75. Mastery was calculated as the number of students scoring at least 75 divided by the number of students evaluated, multiplied by 100%. The percentage for each category was checked against the total of 32 students. The available data do not include individual scores for all students or a class mean that could be independently recalculated. Therefore, the article's analysis uses the category distribution listed in the tables rather than assuming raw scores that are not available.

The analysis was descriptive-comparative. The frequency and percentage of mastery at baseline were compared with those in Cycle I and Cycle II. Differences in mastery are expressed in percentage points rather than relative percentages to avoid ambiguity. Baseline mastery was 8/32 or 25.00%; Cycle I was 22/32 or 68.75%; and Cycle II was 31/32 or 96.875%, rounded to 96.88%. Thus, the change from baseline to Cycle I was 43.75 percentage points, the change from Cycle I

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to Cycle II was 28.125 percentage points, and the change from baseline to Cycle II was 71.875 percentage points. Values are rounded to two decimal places where necessary.

The success criterion for the action was a minimum class mastery of 80%. Based on this criterion, Cycle I had not yet reached the target, with a mastery of 68.75%, whereas Cycle II exceeded the target with a mastery of 96.88%. This analysis does not include inferential significance testing because complete individual score data were not available and the research design was aimed at classroom improvement. Effect size and N-gain were not calculated because the required raw score data were not fully available.

Regarding ethics, the available information is insufficient to confirm an ethics committee approval number, participant consent procedures, or formal institutional approval. The article does not fabricate this information. Before submission to a journal, the author needs to confirm whether school permission, consent for the use of student data, and an ethics statement are required by the journal or institution. Information on the timing of the research also needs to be confirmed because the dates on the observation sheets are not all in chronological order. This documentation limitation is noted for follow-up and is not used to negate the available descriptive results.

3. RESULTS AND FINDINGS

At baseline, the learning outcome data recorded that 8 of 32 students were in the 75–80 score range, while 24 students scored below 75. No students were in the 81–90 or 91–100 categories. With a KKM of 75, the baseline mastery rate was 25.00%, while 75.00% of students had not yet achieved mastery. This distribution shows that the majority of students had not yet met the minimum threshold set for OHS learning. This finding became the reason for designing actions that gave students greater opportunities to analyze problems, discuss, and receive feedback.

Table 1 summarizes the reported change in the distribution of score categories. Percentages are calculated based on a total of 32 students and may be rounded to two decimal places.

Table 1. Distribution of OHS learning outcomes by score category.

Score category	Baseline n (%)	Cycle I n (%)	Cycle II n (%)
Very good (91–100)	0 (0.00)	13 (40.63)	25 (78.13)
Good (81–90)	0 (0.00)	4 (12.50)	2 (6.25)
Fairly good (75–80)	8 (25.00)	5 (15.63)	4 (12.50)
Not yet mastered (<75)	24 (75.00)	10 (31.25)	1 (3.13)
Total	**32 (100)**	**32 (100)**	**32 (100)**

Note: KKM = 75. Percentages are calculated as frequency divided by 32 and rounded to two decimal places.

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Table 2. Change in OHS learning mastery.

Stage	Students mastered	Not yet mastered	Mastery	Change
Baseline	8/32	24/32	25.00%	—
Cycle I	22/32	10/32	68.75%	+43.75 percentage points
Cycle II	31/32	1/32	96.88%	+28.13 percentage points
Initial–Cycle II	—	—	—	**+71.88 percentage points**

4. DISCUSSION

4.1 Meaning of the Change in Mastery in the Context of CAR

The main finding of the study is the increase in OHS learning mastery from 25.00% at baseline to 68.75% after Cycle I and 96.88% after Cycle II. This change is important for the classroom context studied because baseline mastery showed that three quarters of the students had not yet reached the minimum threshold. After two action cycles, only one student remained below the KKM. Thus, the data support the conclusion that during the process of instructional improvement, the distribution of learning outcomes moved toward higher mastery.

In classroom action research, changes between cycles need to be read as part of a process of reflection and practice improvement, not as a test of an isolated effect. The teacher and researcher can adjust the way problems are presented, the support provided during discussion, or the feedback based on students' responses. Although this study does not present a detailed log of every change made between Cycle I and Cycle II, the CAR design provides the context that each subsequent cycle was carried out after the previous cycle had been reviewed. The learning outcome data show that the class target was not reached in Cycle I and was reached in Cycle II.

The magnitude of the change also needs to be described precisely. The increase from 25.00% to 68.75% is 43.75 percentage points; from 68.75% to 96.875% it is 28.125 percentage points. The term percentage points is more appropriate than simply referring to a "percentage increase", because it compares two proportions. Overall, the difference between baseline and Cycle II is 71.875 percentage points. These figures describe the change in class mastery but provide no information about the magnitude of change in the mean score, the score distribution, or the stability of results after instruction ended.

4.2 How PBL Can Support OHS Learning

One pedagogical reason for using PBL is that the problem becomes the organizer of learning activities. In OHS material, students can observe a situation, recognize unsafe conditions, infer causes, search for information, and formulate preventive actions. This structure has the potential to connect conceptual knowledge with the decisions that need to be made in the work environment. For example, a case of a worker falling because of not using PPE requires students to identify the unsafe act, consider the function of PPE, and explain prevention. A case of exposure to hazardous gas directs students to consider whether the PPE matches the type of hazard, rather than merely memorizing the term mask.

The PBL stages used in this study also provide room for collaboration. When students divide tasks, gather information, and compare solutions, they need to articulate the reasons behind their choices. Presentations and responses between groups provide an opportunity to review whether the

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solutions have addressed the problem. The subsequent reflection stage can help students become aware of the parts they have not yet understood. However, this process is only potentially effective if the teacher ensures that all members contribute, information sources are appropriate, and the discussion does not stop at short answers without reasons. PBL that consists only of dividing students into groups without investigation and critical evaluation is not sufficient to guarantee deep learning.

The relevant literature supports the general relevance of PBL, although contextual fit must be considered. Yunansah et al. (2022) examined the implementation of PBL in vocational high school instruction, while Rahman et al. (2023) presented a meta-analysis related to PBL in science learning. These sources can be used to situate this study within a broader discussion of problem-based learning. However, this article does not extrapolate the magnitude of results from other studies to the TKR class, because the characteristics of the material and the research designs are not identical. The findings of this study are contextual: one class, one school, two cycles, and one learning outcome indicator summarized through score categories.

4.3 The Function of Digital Evaluation and Feedback

Quizizz was used in the lesson materials to carry out evaluations or quizzes related to OHS material. Digital quizzes can simplify the presentation of questions and allow results to be known quickly. This information can help teachers identify misconceptions and provide further explanation. In problem-based learning, formative evaluation should not merely serve to give a score but should also inform the next steps: which concepts need clarification, which reasoning is still weak, and how students can improve their answers.

Nevertheless, the available data do not separate the outcomes obtained from PBL activities from those resulting from the use of Quizizz. There was no group that experienced PBL without Quizizz or Quizizz without PBL. Therefore, the increase in mastery cannot be attributed specifically to the digital platform. The results may be related to the entire learning sequence, including repetition of material, group work, presentations, feedback, practice questions, and teacher attention. Future research could design a more controlled comparison if its main objective is to test the additional contribution of Quizizz.

The distinction between an evaluation medium and a learning model is also important for teachers' practice. Quizizz does not replace learning about risks, procedures, and safety decisions. If quiz questions measure only recall, teachers need to complement them with tasks that ask students to explain their reasoning or analyze cases. In OHS, a correct answer to a multiple-choice question is evidence of a certain understanding, but it does not automatically demonstrate the skill of applying procedures in the workshop. Therefore, knowledge assessment should not be equated with observation of safety behavior or assessment of practical performance.

4.4 Implications for Vocational Education and OHS Learning

For TKR teachers, the results of this study offer an example that OHS instruction can be designed with problems closely related to workplace risks. Cases need to be adapted to the targeted competencies and students' experiences. Problems that are too simple may encourage superficial answers, while cases that are too complex without support may cause students to lose direction. Teachers can start with short cases, ask students to identify facts and questions, and then provide sources or worksheets to guide the investigation. Group solutions need to be assessed not only on

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the appropriateness of their conclusions but also on the quality of reasoning, use of information, and the fit between preventive actions and the hazards identified.

Group organization needs to be designed explicitly. Teachers can ask each member to take on a role, such as fact recorder, information searcher, risk analyst, recommendation writer, or presenter. Roles need not be rigid, but they help prevent domination by a few students. During discussion, teachers can pose prompting questions such as: what evidence shows that this condition is hazardous, who could be affected, which action is most urgent, and how can we ensure that the solution can be implemented? Questions like these help students develop evidence-based reasoning rather than guessing the answer the teacher wants.

In OHS material, technical accuracy must be a priority. Students need to distinguish hazards from risks, select PPE according to the type of hazard, understand safe work procedures, and recognize that prevention cannot always be achieved through PPE alone. Teachers need to check the proposed solutions so that dangerous or overly simplified conclusions about risk management do not emerge. When cases involve chemicals, machinery, or high-risk conditions, the sources students use must be reliable and teachers must provide technical clarification. PBL does not mean leaving students to discover all safety procedures on their own without expert supervision.

The results also underline the importance of using evaluation for improvement. In Cycle I, the mastery rate of 68.75% did not yet meet the 80% target, so the action needed to continue. In Cycle II, mastery reached 96.88%. This pattern may encourage teachers not to judge success solely on the basis of a single test but to use evaluation results to determine follow-up actions. Students who have not yet achieved mastery still require diagnosis of their difficulties and support, not merely a repeat of the test. Because one student had still not reached the KKM after Cycle II, good instructional practice should provide appropriate individual assistance or remediation.

For schools, implementation support need not be limited to the availability of digital devices. Using a quiz platform requires adequate device and network access, but the quality of problems, worksheets, rubrics, and the teacher's ability to provide feedback are equally important. Schools can encourage teachers to develop a bank of OHS cases relevant to the automotive workshop, update learning resources, and engage in collaborative reflection. Case materials can also be linked to the school workshop's standard operating procedures so that knowledge learning supports a consistent safety culture.

4.5 Limitations of the Evidence and Strength of Inference

This study has several limitations that need to be considered when reading its results. First, the CAR design was carried out in one class without a comparison group. Therefore, the change in mastery cannot be attributed exclusively to PBL. Other factors such as repeated exposure to the material, practice, study time, teacher attention, or students' development during the study may also have contributed. This design is suitable for evaluating classroom practice but was not designed to prove that PBL will produce the same impact in a broader population.

Second, the data presented are category distributions, not complete individual scores. The distributions allow the proportion of students achieving mastery to be calculated but do not allow examination of each student's score change, the mean score, standard deviation, instrument reliability, or effect size. The research narrative mentions a mean score of 100 in Cycle II, but this statement cannot be verified from the available category table. Using this figure without raw data

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would create an impression of precision that is not supported. This article therefore uses category frequencies and mastery percentages as the main results.

Third, the learning outcome instrument is not described in sufficient detail to assess its validity and reliability. The source mentions the use of evaluation questions and Quizizz but does not provide a complete test blueprint, the number of items, examples of all questions, expert validation results, or item quality analysis. Therefore, the results need to be interpreted as achievement on the evaluation used in the study, not as a comprehensive measure of all dimensions of OHS competence. Mastery of theory also cannot be equated with safe behavior during practice.

Fourth, the observation data in the appendix take the form of checklists and are not summarized into consistent implementation scores. In addition, several dates on the observation sheets do not follow the order of the cycle and meeting labels. This discrepancy needs to be clarified by the author before publication. Without a confirmed chronology, the article does not add implementation dates to the methods narrative. This documentation limitation affects the precision of process reporting, although the distribution of learning outcomes at the three stages is presented explicitly.

Fifth, the learning context included several components running simultaneously: PBL, group discussion, presentations, exercises or quizzes, and feedback. No design was available to separate the contribution of each component. Future research could use a comparative design to test whether adding Quizizz provides benefits beyond PBL alone, or collect more detailed process data to understand the learning mechanisms. Further research could also measure retention after several weeks, hazard identification skills, the quality of case analysis, and procedural compliance through practical rubrics.

Sixth, the study focused on one class and one school. The results provide useful information for that context, but generalization to schools with different facilities, curricula, teachers, or student characteristics must be made with caution. Replication in other schools, other vocational subjects, and more diverse groups of students could clarify the conditions that support the implementation of PBL. Further research could also adequately report participant characteristics, consent procedures, instrument validation, and anonymized score data so that readers can assess the strength of the evidence more fully.

4.6 Directions for Further Research

Further research should broaden the learning outcome indicators. For OHS, these indicators could include conceptual knowledge, the quality of reasoning in cases, accuracy in selecting PPE, the ability to sequence safe procedures, and behavior observed during practice. Each indicator needs to be measured with an appropriate instrument. Written tests can be used for knowledge, analytic rubrics for case solutions, and structured observation sheets for behavior or skills. Using multiple data sources can reduce dependence on a single outcome measure.

In addition, reporting of the action process needs to be more transparent. Researchers can document the changes made from Cycle I to Cycle II, the types of difficulties identified, the forms of support provided, and the reasons for deciding to continue or stop the cycles. This information will help readers understand how the results developed, not merely that the proportion of mastery changed. Anonymized individual score data could allow a more complete distributional analysis without revealing students' identities.

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If the research aim is to test the effectiveness of the digital component, a comparative design should be considered. For example, a class using PBL with Quizizz could be compared with a class using PBL with non-digital evaluation, while ensuring equivalence of material and learning time. Such a design requires ethical consideration, an adequate sample size, and valid instruments. If the aim remains classroom improvement, CAR can be retained, but claims must remain focused on the changes observed within the context of the action.

Overall, the results of this study are strongest as descriptive evidence that class mastery increased during two cycles of implementing problem-based learning. Their practical value lies in the example of applying contextual OHS problems and using digital evaluation in the improvement process. The limits of interpretation are also clear: the data do not prove an isolated effect of PBL or Quizizz, do not verify the class mean claimed in the source narrative, and do not yet demonstrate retention or long-term safety behavior.

4.7 Considerations for Implementation and Reporting

When applying these results to other classes, teachers need to distinguish between achieving the KKM and broader work competence. The KKM serves as a decision threshold for judging whether students meet the assessment criteria used. However, occupational safety is multidimensional: students may understand concepts in a test but not necessarily apply them consistently when dealing with tools, time pressure, or changing practice environments. Therefore, test mastery is a relevant but limited indicator. A more comprehensive OHS assessment should combine knowledge questions, case analysis, procedural demonstrations, and behavioral observation conducted with clear criteria.

In PBL, the quality of the problem needs to be a primary concern. Cases should not merely ask students to state rules but should provide enough information for them to weigh several options. Students can be asked to identify what is known, what is not yet known, what sources of information are needed, and what criteria are used to assess solutions. Teachers can assess the quality of the process with a simple rubric covering hazard identification, explanation of causes, appropriateness of preventive actions, use of sources, collaboration, and clarity of communication. Such a rubric will help connect learning objectives with student activities and provide more specific feedback than right-or-wrong scores alone.

Reflection between cycles should ideally be documented explicitly. If some students have not yet achieved mastery after Cycle I, the researcher needs to explain whether the difficulties relate to understanding particular concepts, the ability to read questions, group participation, access to technology, or time to complete tasks. Adjustments in Cycle II can then be linked to those difficulties. In the available source, mastery results per cycle are clearly visible, but the detailed reasons for each adjustment are not presented completely enough to establish a mechanistic relationship. Therefore, this article does not fabricate a list of changes as if they had been implemented; instead, the need to document reflection becomes a recommendation for subsequent classroom research.

Another methodological point is the difference between process observation data and test results. Observation can provide context about the implementation of the action, such as whether the teacher presented the problem, guided the discussion, or engaged students in reflection. Test results show achievement on the evaluation instrument. The two types of data can complement each other but cannot substitute for each other. In this source, the observation checklists show that the various learning stages were planned and observed, while the learning outcome tables serve as the main

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basis for comparing mastery. Because the observation data have no clear total score, the article does not convert them into quantitative figures that were not reported.

To strengthen the manuscript before publication, the author should retain the anonymized score sheets underlying the baseline, Cycle I, and Cycle II tables. These data would allow verification of whether the same students were assessed at each stage, how individual scores changed, and whether the mean mentioned in the narrative is correct. The author could also include the test blueprint and sample items as supplementary material if the journal permits. The availability of supporting evidence increases transparency and helps readers judge whether the conclusions drawn are commensurate with the information available.

In terms of contribution, this article need not claim that the use of PBL is an innovation that has never been done before. A credible contribution can take the form of structured documentation of how one teacher and one class responded to a mastery problem through case-based learning, and how mastery changed over two cycles. This added value will be stronger if readers obtain a clear picture of the context, the learning syntax, outcome indicators, and data limitations. In educational articles, limitations are not weaknesses to be hidden; reporting the limits of inference is part of scientific integrity and helps readers use the results appropriately.

5. CONCLUSION AND SUGGESTIONS

Classroom action research involving 32 Grade XII TKR students at SMK Utama Kepanjen showed that OHS learning mastery increased over two learning cycles implementing PBL. Mastery at baseline was 25.00% (8 students), rose to 68.75% (22 students) after Cycle I, and reached 96.88% (31 students) after Cycle II. With a class success criterion of at least 80%, the target was not reached in Cycle I but was exceeded in Cycle II. The change in mastery from baseline to Cycle II was 71.88 percentage points.

The reported instruction organized students to analyze OHS cases, work in groups, search for information, formulate and present solutions, receive feedback, and take evaluations that included Quizizz. This sequence is relevant for connecting safety concepts with contextual work problems. Nevertheless, the single-class design without a comparison group and data consisting mainly of score categories limit the conclusions. The findings cannot isolate the contribution of PBL from Quizizz or other learning components, and they do not prove changes in practical skills or long-term safety behavior.

As a practical implication, vocational teachers may consider PBL for OHS instruction by ensuring relevant cases, guided investigation, division of group roles, technical clarification, and feedback that helps students improve their understanding. Further research needs to supplement raw score data, instrument validation, reporting of changes between cycles, the chronology of observations, and the measurement of practical skills. Before the article is submitted to a journal, the author also needs to re-examine the claim regarding the Cycle II mean and the dates in the appendix so that the reporting is fully consistent with the source data.

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