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Developing PBL-based Student Worksheet to Foster Mathematical Literacy in Probability Topic

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Abstract

The mathematical literacy ability of students in Indonesia is still relatively low, especially at the Vocational High School (SMK) level. One solution that can be implemented is the development of learning media in the form of Student Worksheets (LKPD) based on mathematical literacy using the Problem-Based Learning (PBL) model. This study aims to develop and test the validity and practicality of mathematical literacy-based LKPD on the topic of compound probability events. Using the Research and Development (R&D) method and the ADDIE development model, which consists of five stages—Analysis, Design, Development, Implementation, and Evaluation—this research was conducted on 11th-grade students of the Automotive Engineering 4 class at SMK Negeri 3 Yogyakarta. The results show that the developed LKPD was rated as highly valid by subject matter experts (88.13%) and media experts (92.97%). Additionally, students' responses to the practicality of the LKPD reached 93.65%, which falls into the highly practical category. Thus, this LKPD can be used as an effective learning medium to improve the mathematical literacy of vocational high school students.

Keywords: compound probability event, mathematical literacy, problem-based learning, student worksheet

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INTRODUCTION

Mathematics plays an essential role in daily life. However, learning mathematics is often perceived as difficult by students, especially at the Vocational High School (SMK) level (Nuraeni et al., 2017). The main issue found at SMK Negeri 3 Yogyakarta is the low mathematical literacy ability of students and the lack of learning media that support the development of this ability.

Mathematical literacy refers to an individual's ability to formulate, apply, and interpret mathematics in various contexts (OECD, 2021). In practice, mathematical literacy is crucial in helping students understand, analyze, and solve problems related to mathematics in everyday life.

To address this issue, learning media that can enhance students' mathematical literacy skills is needed. One medium that can be developed is a Student Worksheet (LKPD) based on mathematical literacy using the Problem-Based Learning (PBL) model. This model was chosen because it emphasizes solving real-world problems, thereby improving critical thinking skills and a deeper understanding of mathematical concepts (Sofyan & Komariah, 2016).

This study aims to develop a mathematical literacy-based LKPD using the PBL model on the topic of compound probability events and to test its validity and practicality.

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THEORETICAL FRAMEWORK

In this paper, we address the theoretical framework for students' worksheet, mathematical literacy, and problem-based learning. These three topics are essential in developing the understanding of the PBL-based students' worksheet to foster mathematical literacy.

Students' worksheet

Students' worksheet is a learning medium that provides guidance for students in understanding a learning concept. It can include instructions, questions, and tasks that help students comprehend the taught material more deeply. A well-designed worksheet can increase student engagement and encourage independent learning (Sulistyorini et al., 2018).

There are various types of worksheet used in learning, including: (1) explorative worksheet, encourages students to explore concepts independently before receiving explanations from the teacher; (2) confirmative worksheet, reinforces students' understanding of previously learned concepts through exercises and additional assignments; (3) experimental worksheet, used in experimental-based learning where students conduct experiments or simulations to understand mathematical concepts practically; (4) project-based worksheet, includes project or case study tasks requiring students to work within a specific timeframe with an outcome such as a report or presentation; and (5) problem-based worksheet, used in learning models like Problem-Based Learning (PBL), where students are given real-world problems to solve by applying learned concepts.

Mathematical literacy

Mathematical literacy, according to the OECD (2021), is an individual's capacity to formulate, use, and interpret mathematics in various contexts. It encompasses an understanding of concepts, procedures, facts, and tools used in real-world problem-solving. The PISA 2022 framework divides mathematical literacy into three main domains: process, content, and context.

The process domain describes the cognitive activities involved in solving mathematical problems, such as: formulating (translating real-world problems into mathematical representations), employing (applying mathematical tools and procedures), and interpreting and evaluating (drawing conclusions and reflecting on results). While the students perform the problem-solving activities, they also apply the reasoning skills at all stages of problem-solving.

The content domain includes fundamental mathematical concepts and skills. It generally covers: quantity (numbers and operations), uncertainty and data (statistics and probability), change and relationships (algebra and functions), and space and Shape (geometry and measurement).

The context domain refers to the real-life settings where mathematics is applied. It includes: personal (daily life, finance, home management), occupational (workplace-related mathematics), societal (civic engagement, public policy, environment), and scientific (academic and technological applications).

Problem-based learning

Problem-Based Learning (PBL) is a learning model that emphasizes problem-solving as the initial step in acquiring and applying new concepts. The process involves: (1) Orientation to the problem: The teacher presents real-world problems

related to the learning material; (2) Organizing students for learning: Students discuss the problem in groups, identify necessary information, and plan effective solutions; (3) Guiding investigations: Students research information from various sources, while the teacher acts as a facilitator; (4) Developing and presenting solutions: Each group presents their findings and solutions; (5) Analyzing and evaluating the problem-solving process: Students and teachers reflect on the learning experience and the effectiveness of their solutions (Hung, 2016; Hmelo-Silver, 2004; Savery, 2006).

The PBL process begins with orienting students to a problem, where the teacher presents real-world problems relevant to the learning material. Students then observe and identify the problem, while the teacher guides them in understanding the background of the problem and connecting it to the mathematical concepts being studied.

After understanding the problem, students are organized into groups for collaborative learning. The teacher forms discussion groups and assigns tasks that must be completed together. Students begin discussing the problem, identifying the necessary information, and planning effective solution strategies.

The next stage is guiding the investigation, both individually and in groups. At this stage, students search for information from various sources such as books, journals, or other learning media. The teacher acts as a facilitator, providing direction and clarification when needed. Students then explore various possible solutions to solve the given problem.

After the investigation process, students develop and present their work. Each group presents the results of their analysis and the solutions they have devised. The teacher and other students then provide feedback and discuss the answers found to deepen their understanding.

The final step in the PBL model is analyzing and evaluating the problem-solving process. The teacher helps students assess the effectiveness of the solutions provided and offers guidance for further improvement. Students are also encouraged to reflect on what they have learned and how the acquired concepts can be applied to other real-world situations. Through these stages, PBL not only enhances conceptual understanding but also fosters critical thinking and deeper problem-solving skills.

RESEARCH METHOD

This study employs the Research and Development (R&D) method using the ADDIE model, which consists of five stages, namely analysis, design, development, implementation, and evaluation (Aldoobie, 2015; Nichols Hess & Greer, 2016).

Analysis

In this stage, we do the following activities: interviewing mathematics teachers to identify student needs; observing ongoing learning processes to determine challenges in understanding compound probability; conducting literature studies on mathematical literacy and the PBL model; and identifying the characteristics of the target students.

Design

In this stage, we do the following activites: structuring the worksheet according to the PBL model; designing the worksheet layout using design applications, such as Canva; determining mathematical literacy indicators to be integrated; and outlining PBL-based learning sequences.

Development

In this stage, we do the following activities: creating an engaging and interactive worksheet; conducting initial validation with subject matter and media experts; testing the clarity of instructions and the appropriateness of exercises; and revising based on expert feedback before student trials.

Implementation

In this stage, we do the following activities: applying the worksheet in the 11th-grade students of automotive engineering at SMK Negeri 3 Yogyakarta, a vocational high school in Yogyakarta; observing student engagement and collecting feedback through questionnaires and interviews; and using purposive sampling to select students with varying comprehension levels.

Evaluation

In this stage, we do the following activities: formative evaluation: conducted during development and trials to gather feedback; and summative evaluation: conducted to assess the worksheet's validity and practicality based on student responses and teacher feedback.

Selection of research subjects

The research subjects were selected using the purposive sampling method, choosing students with varying levels of understanding to ensure that the developed student worksheet could be used by students with different comprehension levels. A small trial was conducted on five students, while the main trial was conducted on 29 students from 11th grade students of automotive engineering at SMK Negeri 3 Yogyakarta.

Aspects observed in data collection

Observation

The observation targeted the students' interaction with the worksheet, the level of student engagement in group discussions, the difficulties encountered by students while working on the worksheet, and the effectiveness of the PBL learning model in enhancing students' understanding.

Interview

The interview targeted the students' opinions on the ease of use and benefits of the worksheet, the feedback from teachers regarding the implementation of the worksheet in learning, and the challenges faced by students while using the worksheet.

Questionnaire

The questionnaire targeted the validity of the worksheet based on assessments by subject matter experts and media experts, the practicality of the worksheet based on students' responses, and the students' satisfaction in using the worksheet.

RESULTS AND DISCUSSION

Product highlight

The worksheet has several features. First, it enhances the student engagement and motivation. The worksheet captures students' interest and encourages active participation in the learning process. Second, it supports problem-based learning. It enables students to understand concepts through individual and group problem-solving (See Figure 1). Third, it improves critical thinking and mathematical literacy skills. The PBL model helps students analyze problems and connect mathematical concepts with real-life situations. Forth, it is user-friendly and practical for teachers. The worksheet facilitates guided learning and makes it easier for teachers to assess students' understanding. Fifth, it encourages independent learning. The design of the worksheet promotes student autonomy in mastering mathematical concepts. These benefits demonstrate that mathematical literacy-based LKPD using PBL can be an effective alternative learning tool to enhance students' comprehension and critical thinking abilities.

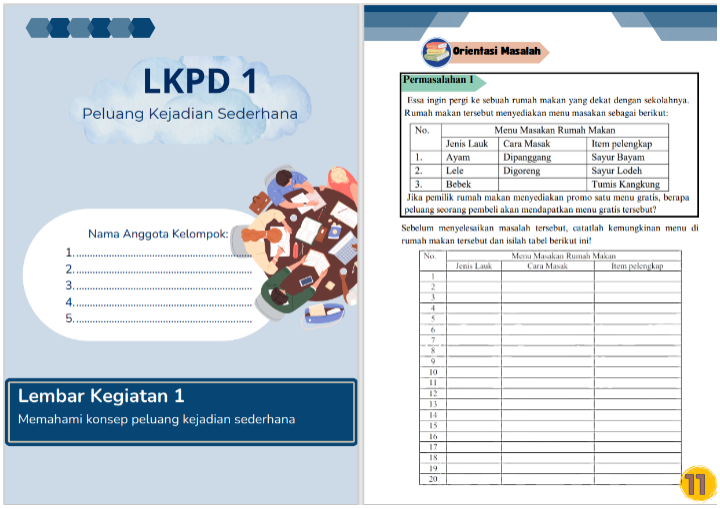

Figure 1. Worksheet on simple probability with orientation to problem.

Validation results

The validation results indicate that the developed LKPD has a high validity level, with an 88.13% rating from subject matter experts and 92.97% from media experts.

Practicality results

In terms of practicality, student responses show that the LKPD is highly practical, with an average score of 93.65%. These findings align with previous studies, confirming that the PBL model enhances students' conceptual understanding and critical thinking skills (Afifah et al., 2020).

CONCLUSION

The development of mathematical literacy-based LKPD using the PBL model has been proven valid and practical for teaching mathematics in vocational high schools. This LKPD not only helps students understand compound probability events but also improves their critical thinking and mathematical literacy skills. Teachers are encouraged to use this LKPD as a teaching resource, and future research should explore its effectiveness at different education levels.

DECLARATION

Author Contribution

All authors contribute in the research process, such as collecting the data, analyzing the data, and writing the manuscript. All authors approved the final manuscript.

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This research did not receive any funding.

Conflict of Interest

Both authors declare that they have no competing interests.

Ethics Declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Emerging Mathematics Education (IJEME) in maintaining high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

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