

DEVELOPMENT OF A PROBLEM-BASED LEARNING MODULE ON DATA PRESENTATION TO ENHANCE STUDENTS' MATHEMATICAL REPRESENTATION ABILITY

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ABSTRACT This study aimed to develop and validate a mathematics teaching module on data presentation content based on the *Problem-Based Learning* (PBL) model to facilitate the mathematical representation ability of Phase D (Grade VII) students. The study employed a *Research and Development* (R&D) approach using the ADDIE model, which includes the analysis, design, development, implementation, and evaluation stages. Research instruments consisted of expert validation sheets and student response questionnaires. The validation results indicate that the developed module achieved an average expert score of 91.11%, categorized as very valid. Practicality testing showed average student response scores of 91.17% in the small-group trial and 86.93% in the large-group trial, indicating that the module is highly practical. These findings suggest that the developed PBL-based teaching module is feasible for classroom implementation and effective in supporting students' mathematical representation ability in data presentation learning. This study contributes to the development of contextual instructional materials based on PBL and provides a foundation for future research examining the effectiveness of the module through experimental designs.

Keywords: problem-based learning, mathematics teaching module, data presentation, mathematical representation ability

ABSTRAK Penelitian ini bertujuan untuk mengembangkan dan memvalidasi modul ajar matematika pada materi penyajian data berbasis *Problem-Based Learning* (PBL) guna memfasilitasi kemampuan representasi matematis peserta didik Fase D (kelas VII). Penelitian ini menggunakan pendekatan *Research and Development* (R&D) dengan model ADDIE yang meliputi tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Instrumen penelitian terdiri atas lembar validasi ahli dan angket respons peserta didik. Hasil validasi menunjukkan bahwa modul ajar yang dikembangkan memperoleh skor rata-rata 91,11% dengan kategori sangat valid. Uji kepraktisan menunjukkan skor rata-rata respons peserta didik sebesar 91,17% pada uji kelompok kecil dan 86,93% pada uji kelompok besar, yang mengindikasikan bahwa modul berada pada kategori sangat praktis. Temuan ini

menunjukkan bahwa modul ajar berbasis PBL yang dikembangkan layak digunakan dalam pembelajaran dan mampu mendukung pengembangan kemampuan representasi matematis peserta didik pada materi penyajian data. Penelitian ini memberikan kontribusi terhadap pengembangan bahan ajar kontekstual berbasis PBL dan membuka peluang penelitian lanjutan untuk menguji efektivitas modul melalui desain eksperimen.

Kata-kata kunci: *problem-based learning*, modul ajar matematika, penyajian data, kemampuan representasi matematis

INTRODUCTION

Mathematical representation ability is one of the six process standards outlined by the Indonesian Ministry of Education and Culture (Regulation No. 33 of 2022), alongside reasoning, communication, connection, and problem-solving. This ability enables students to express mathematical ideas through various forms, including diagrams, graphs, symbols, and written explanations (Hutagaol in Oktaviani & Farhan, 2023; Sari et al., 2023). Beyond serving as a means of expression, mathematical representation functions as a cognitive tool that supports conceptual understanding and problem-solving processes (Azzahra et al., 2024; Delfita et al., 2020). In this regard, Yuanita et al. (2018) emphasize that mathematical representation also involves transforming real-world situations into abstract mathematical models.

Effective use of mathematical representations allows students to connect concepts, communicate ideas clearly, and select appropriate strategies when solving complex problems (Riyanto et al., 2024; Syafri, 2017). Representational ability is commonly indicated through students' use of visual representations (such as graphs and tables), symbolic representations (notations and algebraic expressions), and verbal explanations. However, despite its central role in mathematics learning, many students still demonstrate low levels of representational ability, particularly in topics that require the integration of multiple forms of representation.

One such topic is data presentation, which requires students to organize and interpret information using bar graphs, pie charts, line graphs, and tables. Empirical evidence from interviews with mathematics teachers at SMP Negeri 12 and SMP Negeri 32 Pekanbaru indicates that students frequently experience difficulties in interpreting data tables, converting percentages into graphical representations, and applying systematic procedures to solve data-related problems. These challenges are further compounded by the limited availability of teaching materials that explicitly address students' representational needs in data presentation content.

To further substantiate these classroom observations, a diagnostic test involving 32 students was conducted. The results revealed that many students were unable to accurately read data tables, construct pie charts correctly, or clearly articulate the steps involved in solving data presentation problems. These findings confirm that students' difficulties are not incidental but reflect a broader need for instructional

support that specifically targets the development of mathematical representation abilities within this content area.

One potential solution to this issue lies in the use of teaching modules aligned with the Kurikulum Merdeka (Independent Curriculum). Such modules are designed as structured instructional tools that guide learning activities toward clearly defined learning outcomes while also fostering the Profil Pelajar Pancasila (Azzahra et al., 2024; Rahimah, 2022). Teaching modules have been recognized as effective instruments for organizing learning processes in a systematic and coherent manner (Triandini et al., 2023). Nevertheless, the effectiveness of these modules can be further enhanced when they are integrated with an appropriate pedagogical model. Problem-Based Learning (PBL) is a pedagogical model that emphasizes real-world problem-solving and student-centered inquiry. According to Arends (in Kurnia, 2017), the stages of PBL—problem orientation, student organization, guided investigation, presentation of solutions, and reflection—encourage active student engagement and the development of higher-order thinking skills. Previous studies have shown that PBL is more effective than conventional instructional approaches in improving students' mathematical representation abilities (Fitri et al., 2017; Noer & Gunowibowo, 2018).

Support for the use of PBL in developing representational competence is also evident in international research. Stylianides and Stylianides (2021) highlight that structured inquiry-based learning models such as PBL promote deeper conceptual understanding and flexible use of mathematical representations. Similarly, the OECD (2019) emphasizes in the PISA framework that students' ability to represent and reason with data is a crucial competency for addressing real-life problems.

Despite the acknowledged importance of mathematical representation and the documented effectiveness of PBL, studies focusing on the development of validated and practical teaching modules specifically designed for data presentation content, particularly for Phase D students, remain limited. Existing teaching modules are often insufficiently tailored to students' representational difficulties or fail to systematically integrate representation-based learning strategies. Therefore, this study aims to develop a valid and practical teaching module based on the Problem-Based Learning model to improve students' mathematical representation abilities in data presentation content.

METHODS

This study employed a Research and Development (R&D) approach aimed at producing an educational product in the form of a teaching module. According to Mulyatiningsih (2019), R&D is a research method used to develop and evaluate new products through systematic procedures. The development process followed the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

At the Analysis stage, the researcher conducted a needs analysis, curriculum analysis, and analysis of student characteristics. Based on the results of this stage, the Design stage focused on planning the content, learning strategies, and layout of the teaching module. The Development stage involved developing an initial prototype (prototype-1), followed by formative evaluation through expert validation and one-to-one trials with selected students. The Implementation stage consisted of small-group trials involving 6–12 Grade VII students at SMP Negeri 12 Pekanbaru. The Evaluation stage was carried out formatively throughout all stages to determine whether the developed module achieved the intended learning objectives.

The instruments used in this study included expert validation sheets and student response questionnaires. The expert validation sheets were used to assess content validity, including curriculum alignment and accuracy of mathematical concepts, as well as construct validity, which covered clarity of instructions, consistency of structure, and accuracy of mathematical representations. The student response questionnaire measured students' perceptions of the module in terms of visual appearance, material presentation, and ease of use.

To ensure the validity and reliability of the instruments, the validation sheets were reviewed by three experts in mathematics education and instructional design. Inter-rater agreement was applied to examine the consistency of expert judgments. In addition, the student response questionnaire was piloted with a small group of students to assess clarity and internal consistency, with reliability analyzed using Cronbach's Alpha. The criteria for determining the levels of validity and practicality of the teaching module are presented in Table 1.

Table 1. Criteria for Validity and Practicality of the Teaching Module

Score Range	Interval	Category	Interpretation
$85,00\% \leq \bar{V}_a < 100\%$	Very High	Highly Valid / Practical	Meets all criteria excellently; can be used without revision
$70,00\% \leq \bar{V}_a < 85,00\%$	High	Valid / Practical	Meets most criteria well; minor revisions needed
$50,00\% \leq \bar{V}_a < 70,00\%$	Medium	Less Valid / Practical	Requires moderate revision before implementation
$01,00\% \leq \bar{V}_a < 50,00\%$	Low	Invalid / Impractical	Requires major revisions before use

FINDING AND DISCUSSION

Based on the ADDIE development stages, several findings were obtained throughout the development process. In the Analysis phase, a needs analysis, curriculum analysis, and student characteristic analysis were conducted through

interviews with mathematics teachers at SMP Negeri 12 and SMP Negeri 32 Pekanbaru, as well as through a preliminary test of students' mathematical representation ability. Although both schools have implemented the *Kurikulum Merdeka*, teachers reported that they still rely on general teaching modules obtained from the *Platform Merdeka Mengajar*. These modules are not specifically designed to accommodate students' learning characteristics and representational needs, which was reflected in the low level of students' mathematical representation ability identified in the preliminary test. This finding indicates the need for contextualized teaching modules that explicitly support students in solving problems through appropriate mathematical representations.

The analysis of student characteristics showed that Phase D students are generally at the formal operational stage according to Piaget's theory, indicating their potential to engage in abstract and logical reasoning. However, their emotional regulation and learning motivation are still developing, which often leads to difficulties in understanding mathematical concepts. This condition suggests that learning activities should begin with concrete and familiar contexts before gradually introducing more abstract representations, particularly in data presentation content.

The curriculum analysis focused on the *Capaian Pembelajaran* related to data and probability content. Based on this analysis, learning objectives and instructional strategies were formulated in alignment with the *Alur Tujuan Pembelajaran*. The learning objectives emphasize students' ability to conduct statistical investigations by formulating questions that can be answered statistically, collecting data, and processing and interpreting the data to respond to the initial questions. In addition, students are expected to present and interpret data in multiple forms, including tables, bar charts, line diagrams, and pie charts. Each subtopic was allocated two lesson hours, and these objectives served as the foundation for the development of the data presentation teaching module.

In the Design phase, relevant references related to data presentation content were collected, and the layout of the teaching module was developed, resulting in Prototype-1. The module was designed in a printed A4 format (21 × 29.7 cm) to ensure readability and ease of use. Its structure consisted of general information, core components, and attachments, including assessments and student worksheets. Supporting documents such as the *Alur Tujuan Pembelajaran*, expert validation sheets, and student response questionnaires were also prepared and reviewed by academic supervisors. Feedback from supervisors was used to refine the initial prototype to ensure alignment with curriculum standards. The visual design of the developed teaching module is presented in Figure 1.

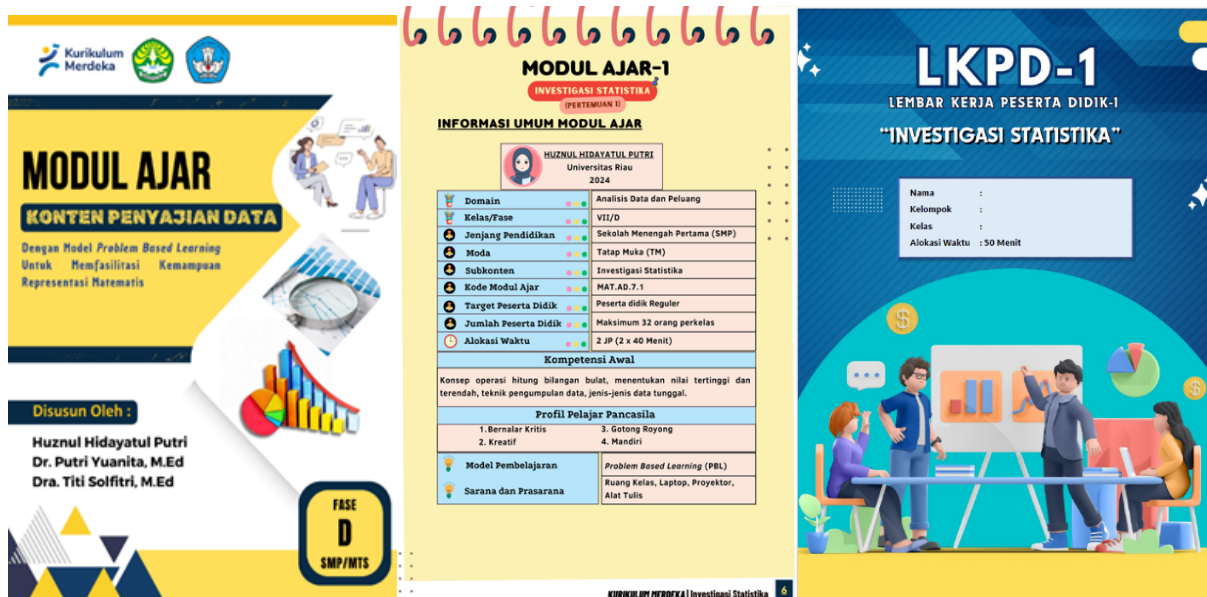


Figure 1. Cover Display of the Teaching Module, and Worksheet

Expert validation was conducted during the Development phase after the teaching module had been fully designed. The validation process involved three experts, consisting of two lecturers in mathematics education and one mathematics teacher. The experts provided several suggestions for improvement. The results of the validation analysis based on the expert validation sheets are presented in Table 4.

Table 4. Results of Teaching Module Validation Analysis

	Assessment Items	Average (\bar{V}_a)	Category
Teaching Module 1	General Information	97,05%	Highly Valid
	Core component	90,34%	Highly Valid
	Attachment	87,73%	Highly Valid
Teaching Module 2	General Information	97,54%	Highly Valid
	Core component	88,75%	Highly Valid
	Attachment	87,96%	Highly Valid
Teaching Module 3	General Information	96,56%	Highly Valid
	Core component	87,98%	Highly Valid
	Attachment	87,50%	Highly Valid
Teaching Module 4	General Information	97,54%	Highly Valid
	Core component	88,56%	Highly Valid
	Attachment	85,64%	Highly Valid

	Assessment Items	Average (\bar{V}_a)	Category
Teaching Module 5	General Information	97,05%	Highly Valid
	Core component	89,92%	Highly Valid
	Attachment	86,57%	Highly Valid
Overall Average		91,11%	Highly Valid

The overall validation score of 91.11% indicates that the developed teaching module falls into the very valid category (Akbar, 2017). Although all components achieved high validity scores, the attachment section—particularly the student worksheets—received slightly lower scores than the general information and core components. This was mainly due to minor layout inconsistencies, repetition of practice questions in several worksheets, and the presence of linguistic inaccuracies. Although these issues were not substantial, they were identified as aspects that could potentially affect clarity and student engagement.

Revisions were made based on expert feedback before proceeding to a one-to-one trial involving three Phase D students. This trial focused on evaluating the readability of the module and the clarity of instructions. Student feedback confirmed the presence of redundant questions and typographical errors, which were subsequently revised prior to the next implementation stage.

The revised module was then implemented in two stages, consisting of a small-group trial involving six students and a large-group trial involving 32 students. Results from the student response questionnaire indicated that students perceived the module as engaging and helpful in understanding data presentation concepts. Students reported that the visual design and clear instructions supported their learning and increased their motivation to participate in classroom activities.

Each student worksheet was also evaluated individually for practicality, including LKPD-1 on statistical investigation, LKPD-2 on presenting data in tables, LKPD-3 on bar diagrams, LKPD-4 on line diagrams, and LKPD-5 on pie charts. While most worksheets were categorized as very practical, LKPD-5 obtained slightly lower scores, particularly in the ease-of-use aspect. This result is likely related to the cognitive demand involved in converting percentages into angles when constructing pie charts, indicating the need for additional instructional support.

Overall, these results demonstrate that the developed teaching module meets the criteria of validity and practicality for use in learning data presentation and provides a strong foundation for supporting students' mathematical representation ability.

The findings of this study indicate that the developed teaching module achieved a very high level of validity and practicality, demonstrating its appropriateness for supporting students' mathematical representation ability in data presentation content. The high validation scores across general information, core components,

and attachments suggest that the module content is well aligned with curriculum demands and pedagogical principles. This result is consistent with previous studies showing that teaching modules developed through systematic R&D procedures and aligned with curriculum structures tend to exhibit strong content and construct validity (Akbar, 2017; Triandini et al., 2023). Moreover, the integration of representation-focused tasks within data presentation activities aligns with findings by Goldin (2002) and NCTM (2000), who emphasize that effective mathematics learning requires students to flexibly use and translate between multiple representations, particularly when dealing with data, graphs, and tables.

Furthermore, the practicality results from small- and large-group trials indicate that students perceived the module as engaging, readable, and supportive of their learning processes. This finding reinforces earlier research demonstrating that Problem-Based Learning can enhance students' representational competence by situating learning within meaningful contexts and encouraging active interpretation of data (Fitri et al., 2017; Noer & Gunowibowo, 2018). The slightly lower practicality score observed in the worksheet on pie charts suggests that tasks involving percentage-to-angle conversion impose a higher cognitive load on students. This observation is supported by international studies highlighting that data visualization tasks, particularly those requiring proportional reasoning, demand explicit scaffolding to prevent cognitive overload (Stylianides & Stylianides, 2021; OECD, 2019). Therefore, while the developed module is effective overall, the findings suggest that additional visual supports or step-by-step guidance may further enhance students' ability to construct and interpret complex data representations.

CONCLUSIONS AND RECOMMENDATIONS

This study developed and validated a mathematics teaching module on data presentation content using the Problem-Based Learning (PBL) model, specifically designed to enhance the mathematical representation ability of Phase D (Grade VII) students. The validation results indicate that the module achieved a very high level of validity, with an average expert judgment score of 91.11%, reflecting strong alignment with curriculum standards, content accuracy, and instructional design quality. In terms of practicality, the module obtained an average student response score of 91.17% in the small-group trial and 86.93% in the large-group trial, indicating that it is perceived as highly practical and user-friendly in classroom implementation.

These findings confirm that the developed module is feasible for instructional use and responsive to students' cognitive and learning characteristics at the junior secondary level. As a phase-specific and context-driven instructional product, this study contributes to the growing body of research on the application of PBL in mathematics education, particularly in facilitating students' use of multiple representations in data presentation learning. Future research is recommended to examine the effectiveness of the module through experimental or quasi-

experimental designs, to implement it across diverse school contexts, and to compare its impact with other instructional models. Additionally, integrating summative assessment components in future module development may provide a more comprehensive evaluation of students' learning outcomes.

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