



Development of a PBL-Based Interactive Storybook to Enhance Elementary Students' Reading Comprehension: A Barrett's Taxonomy Approach

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Abstract: This study aims to develop, test the feasibility, measure the practicality, and examine the effectiveness of a PBL-based interactive storybook entitled "Misteri Bola Kertas" in improving students' reading comprehension skills as measured by Barrett's Taxonomy. The study employed a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, Disseminate) and a mixed-methods design. Data were collected from 26 third-grade students using reading comprehension tests, expert validation questionnaires, and user response questionnaires, and were analyzed using descriptive statistics, N-gain scores, and paired-sample t-tests. The results reveal a significant improvement in students' mean scores from 67.81 to 83.65 (N-gain = 0.56, moderate category; $p < 0.001$). This improvement was supported by expert validation of 81.53% (feasible), student responses of 93.75%, and teacher responses of 88.5% (both categorized as very practical). Although the learning media addresses all five levels of Barrett's Taxonomy, it places particular emphasis on higher-order comprehension skills, specifically reorganization, inferential, and evaluative comprehension, which were identified as the most critical areas of student difficulty. These higher-order thinking processes are facilitated through interactive physical features, including pull-tab mechanisms that support information sequencing, flip-the-flap prompts that encourage synthesis of implicit narrative cues, and Velcro-based activities that engage students in kinesthetic evaluation of moral decisions, each operationalizing a distinct level of Barrett's Taxonomy. These findings contribute to the literature by demonstrating that the structural integration of PBL phases into physical interactive print media constitutes an effective pedagogical approach. The study also offers practical implications for the development of technology-independent instructional media suitable for elementary education contexts in Indonesia.

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Introduction

Reading comprehension is a critical cognitive skill that serves as the foundation for mastering all academic disciplines at the elementary school level. Unlike mere mechanical reading, reading comprehension involves the active process of constructing meaning, evaluating information, and synthesizing knowledge from texts (Kendeou et al., 2020; Mohd Noh et al., 2025). Without this ability, all learning activities risk becoming meaningless. The current state of reading literacy among Indonesian students remains a serious concern. The PISA 2022 results placed Indonesia's reading score at 359 points a decline of 12 points from 2018 making it the lowest achievement since Indonesia first participated in 2000 (OECD, 2023; Bilad et al., 2024). At the elementary school level, although the 2025 National Education Report Card shows literacy achievement in the "Good" category (70.82%), this

figure only reflects attainment of minimum competency. The majority of students are only able to locate explicit information in texts, yet still struggle with higher-order reading tasks such as making inferences, evaluating, and reflecting on reading content.

A similar problem was empirically found at SDN Majalengka Wetan III. Initial diagnostic test results conducted on 20 Grade III students revealed an average reading comprehension score of only 43 out of an ideal score of 100. The most critical weakness was identified in the reorganization indicator (average 33.00), which refers to the ability to analyze, synthesize, and reorganize textual information. This indicator serves as a cognitive bridge between literal and inferential comprehension (Nurbaya, 2019; Koparan, 2025), meaning that weakness at this level has systemic implications for the development of higher-order thinking skills. The primary contributing factor to this problem is the dominance of conventional instructional methods. Indonesian Language learning in Grade III still relies heavily on lectures, question-and-answer sessions, and textbook-based assignments dense with text. Instructional media are limited to whiteboards, even though the school is already equipped with a smartboard that has not been utilized due to limited digital competence among teachers. This condition deprives students of sufficient stimulation to actively and independently construct understanding.

Several prior studies have attempted to address reading literacy challenges through media innovation and instructional approaches. Herawati & Purba (2023) demonstrated that story-based educational learning design can improve reading skills of Grade III elementary students. Rachmawati & Yuliani (2023) showed the effectiveness of the PBL model in improving informational text reading comprehension. Alfazuri et al. (2024) developed an interactive digital comic based on PBL with proven effectiveness. Zahrika & Purwati (2024) developed a PBL-based e-BigBook that showed significant improvement. Triani & Nuryanto (2024) validated the effectiveness of a PBL-based Pop-Up Book for improving elementary students' learning outcomes.

However, an unaddressed research gap remains: no prior study has structurally integrated the PBL model into the interactive physical mechanisms of a printed storybook. Previous studies either tested PBL separately from media or developed digital media requiring technological infrastructure. Yet, the real conditions of many elementary schools in Indonesia particularly in regional areas still face limitations in teachers' digital competence, making interactive print media relevant and practically advantageous.

Theoretically, PBL is particularly well-suited to address the higher levels of Barrett's Taxonomy because both frameworks share a common cognitive demand: moving learners beyond passive information retrieval toward active meaning construction. Barrett's Taxonomy progresses from literal comprehension locating explicitly stated information through reorganization, inferential, evaluative, and appreciative levels, each requiring progressively deeper cognitive engagement with the text (Nurbaya, 2019). PBL mirrors this progression through its five phases: problem orientation activates literal comprehension as students identify what is explicitly stated in the problem scenario; the investigation phase demands reorganization and inferential skills as students synthesize information from multiple sources; and the analysis and evaluation phase directly engages evaluative and appreciative comprehension as students reflect on and judge the solutions they have constructed (Jaganathan et al., 2024; Syamsudin, 2020). This structural alignment suggests that a medium which physically operationalizes PBL phases has the theoretical capacity to scaffold reading comprehension across all levels of Barrett's Taxonomy in a sequential and purposeful manner.

This study addresses that gap by developing a PBL-based interactive storybook entitled "Misteri Bola Kertas" a physical A3-sized print medium integrating all five PBL phases into manipulative interactive mechanisms (Pop-Up, Pull-Tab, Flip-the-Flap, Sliding Mechanism, Velcro Attachment, and Decision Cards). The novelty of this study lies in the structural mapping of PBL phases onto physical interactive features where, for instance, 'Decision Cards' facilitate evaluative comprehension and 'Velcro Attachments' support reorganization skills, directly addressing the higher levels of Barrett's Taxonomy. Specifically, this study aims to: (1) analyze development needs, (2) test product feasibility through expert validation, (3) measure practicality through teacher and student responses, and (4) demonstrate product effectiveness in improving students' reading comprehension ability.

Research Method

This study employed a Research and Development (R&D) method with a mixed-methods approach (qualitative and quantitative). The development model adopted was the 4D model developed by Thiagarajan, consisting of four stages: Define, Design, Develop, and Disseminate. This model was selected because its stages are systematic, detailed, and encompass all analytical aspects required in developing instructional media (Ameriza & Jalinus, 2021).

The Define stage included front-end analysis, student analysis, concept analysis, task analysis, and specification of instructional objectives. The preliminary study was conducted at SDN Majalengka Wetan III, Majalengka District, Majalengka Regency, beginning in December 2025. The Design stage produced a product blueprint in the form of a storyboard for an A3-sized book (29.7 × 42 cm) with 16 pages, printed on 230 gsm Brief Card paper. The Develop stage encompassed physical prototype production, expert validation, revision, and limited field trials. The Disseminate stage was conducted on a limited basis in both print and digital formats (PDF).

The research subjects were 26 Grade III students of SDN Majalengka Wetan III for the 2025/2026 academic year. The sampling technique used was saturated sampling, in which all members of the available population are included as research subjects given that the total population is small and manageable (Sugiyono, 2019). The use of saturated sampling in this study is justified by the fact that the entire Grade III enrollment for the 2025/2026 academic year consisted of only 26 students, making it both feasible and methodologically appropriate to include all of them as subjects. Furthermore, within the context of Research and Development, the Develop stage is designed as a small-scale, limited field trial aimed at obtaining preliminary evidence of product feasibility and effectiveness prior to broader dissemination not to produce statistically generalizable findings (Thiagarajan et al., 1974). Consistent with this framework, this study is explicitly positioned as a pilot study, and the findings should be interpreted as indicative rather than conclusive, with wider-scale replication in schools with varying characteristics strongly recommended in future research.

The validation process involved three expert validators: media expert, language expert, and content expert. Data were collected through a reading comprehension test (30 multiple-choice items based on five Barrett's Taxonomy indicators: literal, inferential, reorganization, evaluation, and appreciation), observation sheets, interviews, needs analysis questionnaires, expert validation questionnaires, and teacher and student response questionnaires. The initial diagnostic test administered to 20 students during the Define stage reflects the number of students present on the day of the pre-study test. The main research (product trial, pretest–posttest, and response questionnaires) involved all 26 enrolled Grade III students for the 2025/2026 academic year. These two data collection activities served

different purposes: the initial diagnostic test functioned as a preliminary study to identify problems, while the pretest–posttest served as the primary instrument for measuring product effectiveness.

The effectiveness testing design used a one-group pretest–posttest design. Quantitative data analysis included: (1) calculation of validation and practicality percentages using a 1–5 Likert scale; (2) calculation of N-Gain scores using Hake's (1999) formula to measure relative improvement; (3) Shapiro-Wilk normality test as a prerequisite assumption for the Paired Sample T-test; and (4) Paired Sample T-test to examine the significance of differences before and after the intervention. The minimum product feasibility criterion was set at 70% (Triani & Nuryanto, 2024), the minimum practicality criterion at 61%, and a product was declared effective if a significant improvement occurred (Sig. < 0.05) with an N-Gain in the moderate to high category.

The reading comprehension test instrument consisting of 30 multiple-choice items was developed based on five Barrett's Taxonomy indicators (Nurbaya, 2019), with the following item distribution: literal (7 items), inferential (9 items), reorganization (3 items), evaluation (5 items), and appreciation (6 items). Item validity was tested using item-total correlation with a threshold of $r \geq 0.30$. Instrument reliability was tested using Cronbach's Alpha, yielding a coefficient of 0.938, which falls in the reliable category based on George & Mallery's (2022) criteria. The initial diagnostic test instrument administered to 20 students during the Define stage was different from the pretest–posttest instrument used during the Develop stage.

Results and Discussion

Development Needs Analysis

The Define stage revealed an extremely high urgency for product development. The needs questionnaire administered to three educational practitioners (Grade III Teacher, Grade IV Teacher, and School Principal) yielded an average percentage of 88.20% (Very High category). Meanwhile, the needs questionnaire administered to 26 students yielded an average of 86.12% (Very High category). The detailed results of the needs analysis are presented in Table 1.

Table 1. Needs Analysis Results of Teachers, School Principal, and Students

No	Aspect	Respondent	Percentage	Category
1	Learning Conditions	Teachers & School Principal	80.56%	High
2	Need for Interactive Media	Teachers & School Principal	91.67%	Very High
3	Readiness for PBL Model	Teachers & School Principal	88.89%	Very High
4	Reading Difficulties	Students	85.82%	Very High
5	Need for New Media	Students	94.23%	Very High
6	PBL Readiness (Students)	Students	84.62%	Very High

Two critical findings from this needs analysis deserve emphasis. First, the Need for New Media aspect from the students' perspective reached the highest percentage (94.23%), even surpassing the perceived need from teachers (91.67%). This indicates that students directly experienced the inadequacy of the media currently used. This condition aligns with

the arguments of Valencia & Wardaya (2024) and the findings of Juliati et al. (2025) that interactive storybooks are specifically designed to address children's boredom with conventional media while simultaneously improving reading comprehension. Second, the high readiness of both students and teachers for the PBL model (84.62% and 88.89% respectively) indicates that the school's learning ecosystem already supports PBL implementation, but lacks media capable of directly operationalizing that model in the classroom.

The initial ability test further reinforces this urgency. Of the 20 students who participated in the diagnostic test, the class average was only 43, with the reorganization indicator recording the lowest score (33.00). This finding is consistent with Fadhillah et al. (2024), who found that the most prominent weakness in elementary students' reading comprehension lies in identifying the main idea and answering comprehensive questions. The fact that the reorganization indicator which serves as a cognitive bridge between literal and inferential comprehension (Nurbaya, 2019; Kendeou et al., 2020) recorded the lowest score has serious implications: weakness at this level will impede the development of the entire hierarchy of reading comprehension skills above it.

Product Feasibility Based on Expert Validation

The PBL-based interactive storybook produced is a 16-page A3-sized printed book that integrates the five PBL phases into physical interactive mechanisms in an integrated manner. Each PBL phase is not merely presented as a verbal activity guide, but is operationalized through specific mechanical features. Table 2 summarizes the mapping between PBL phases, interactive features, and their pedagogical functions.

Table 2. Mapping of PBL Phase Integration and Interactive Storybook Features

PBL Phase	Book Pages	Interactive Features	Pedagogical Function
Problem Orientation	pp. 1–4	Pop-Up V-Fold, Sliding Pull-Tab	Concretely visualizing conflict; training inferential reading
Organizing Students & Investigation	pp. 5–8	Flip-the-Flap (Discussion), Pull-Tab 'Tahukah Kamu?', Slider	Encouraging retrieval of hidden information; training reorganization
Developing & Presenting Results	pp. 9–10	Flip-the-Flap, Velcro Attachment	Kinesthetic engagement; training evaluation of moral values
Analysis & Evaluation	pp. 11–12 + Game	Pop-Up V-Fold, Decision Cards, Word Puzzle, Word Search	Reinforcing all reading comprehension indicators

Following the physical production process and revisions based on supervisor input, the product was validated by three expert validators. The validation results are summarized in Table 3.

Table 3. Expert Validation Results of the PBL-Based Interactive Storybook

No	Validator	Assessment Aspects	Percentage	Category
1	Media Expert	Visual Display, Physical Interactive Mechanisms, Illustration & Interactivity	91.25%	Very Feasible
2	Language Expert	Clarity, Communicativeness,	73.33%	Feasible

		Dialogic Quality, Language Rules, Consistency		
3	Content Expert	Content Appropriateness, Story Content & PBL Integration, Language	80%	Feasible
	Overall Average		81.53%	Feasible

The overall validation average percentage of 81.53% exceeds the minimum feasibility threshold of 70% established by Triani & Nuryanto (2024), thereby declaring the product feasible for trial. The highest rating was given by the media expert (91.25%), indicating that the visual design, physical interactive mechanisms, and overall product presentation meet the standards of quality instructional media. Sitorus et al. (2025) stated that well-designed interactive learning media are capable of attracting students' attention and creating an enjoyable learning atmosphere, consistent with the finding of Juliati et al. (2025) that integrating interactive elements into print media significantly improves elementary students' reading comprehension.

The lowest rating came from the language expert (73.33%), particularly on the aspects of language rule compliance (60%) and appropriateness to students' developmental level (70%). An in-depth analysis of the validator's feedback reveals that the mismatch between the language style used in the storybook and the linguistic characteristics of Grade III students primarily stems from sentence structure complexity: several narrative passages employed compound-complex sentence constructions with multiple embedded clauses, whereas Grade III students at the concrete operational stage process information most effectively through short, declarative, and contextually grounded sentences (Yunaini & Winingsih, 2022). This structural complexity reduced the text's readability and risked creating cognitive overload that would impede rather than facilitate reading comprehension. Although language style consistency reached 100%, this uniformity did not fully meet the readability criteria appropriate for the characteristics of Grade III elementary students, confirming Rolla et al.'s (2021) finding that effective reading comprehension requires texts accessible to the reader's background knowledge and cognitive capacity. Accordingly, all product revisions carried out included: (1) visually separating the narration and dialogue sections into distinct formats; (2) replacing decorative fonts in the main text with more readable fonts; (3) simplifying sentence structures by breaking compound-complex sentences into shorter declarative units; (4) correcting punctuation errors; and (5) adding a QR code linking to the digital version of the book as an accessibility extension before the product entered the field trial stage. Documentation of revision results based on comments and suggestions from the media, language, and content experts is presented in Figure 1.



Figure 1. Final Product of the PBL-Based Interactive Storybook

Product Practicality Based on User Responses

The practicality test was conducted after learning using the PBL-based interactive storybook on March 10–11, 2026. Student responses across three aspects showed very high values: visual and physical media display (95.19%), ease of use and readability (92.31%), and benefits and motivation (93.75%), with an overall average of 93.75% (Very Practical category). Teacher responses showed a complementary but distinct pattern: the benefits aspect received a perfect rating (100%), media presentation (91.6%), language (87.5%), and content feasibility (75%), with an average of 88.5% (Very Practical category).

The divergence between student and teacher ratings provides important interpretive insights. Students evaluated from the perspective of direct learning experience—the visual appeal and physical interaction triggered high enthusiasm, consistent with Piaget's cognitive principles that Grade III children (ages 9–10) in the concrete operational stage require concrete visual stimuli and direct experience (Yunaini & Winingsih, 2022; Hayat et al., 2024). Teachers, evaluating from a practitioner's perspective, gave the highest appreciation to the benefits aspect (100%), demonstrating their confidence in the product's pedagogical potential, while the more moderate rating on content feasibility (75%) reflects a critical assessment of content alignment with curricular demands.

These practicality findings also validate the advantages of interactive print media in the context of limited digital infrastructure. This product requires no digital competence, electricity, or internet connection to operate, yet is capable of delivering a learning experience as interactive as digital media. This aligns with Mayer's (2021) cognitive theory of multimedia, which holds that the effectiveness of instructional media does not have to depend on the level of technological sophistication, but rather on the appropriateness of instructional design to the cognitive processes of learners.

Effectiveness on Reading Comprehension Ability

The product trial was conducted in a single learning session (March 11, 2026) using a one-group pretest–posttest design. Before being analyzed using the Paired Sample T-test, statistical prerequisites were met: the Shapiro-Wilk normality test yielded pretest sig. = 0.234 and posttest sig. = 0.084 (both > 0.05, normally distributed), while the Levene homogeneity test yielded sig. = 0.354 (> 0.05, data are homogeneous). Descriptive and inferential statistics are summarized in Table 4.

Table 4. Descriptive Statistics, N-Gain, and Paired Sample T-test

Data	Pre-test	Post-test	N-Gain	Category
Number of Students	26	26	-	-
Maximum Score	90	100	-	-
Minimum Score	40	60	-	-
Mean Score	67.81	83.65	0.56	Moderate
Standard Deviation	15.057	12.756	-	-
Sig. (2-tailed)	-	-	<0.001	Significant

Source: SPSS version 27 output; Primary research data (2026)

The Paired Sample T-test yielded $t = -10.504$ with Sig. (2-tailed) < 0.001 (< 0.05), thereby rejecting H_0 and proving that there is a significant difference in reading comprehension ability before and after using the product. The mean score increased from 67.81 on the pretest to 83.65 on the posttest (a difference of 15.84 points), with an N-Gain of 0.56, which falls in the moderate category ($0.30 \leq g \leq 0.70$). An N-Gain in the moderate category within the context of a single learning session is a meaningful indicator, given the limited duration of the intervention.

An equally significant finding is the decrease in standard deviation from 15.057 (pretest) to 12.756 (posttest). This decrease indicates that the media was not only effective in raising the class average, but also succeeded in narrowing the achievement gap among students. Students with initially lower abilities gained greater benefit, resulting in a convergence of achievement between high- and low-ability groups. This aligns with the inclusive learning principles in the Merdeka Curriculum.

The pedagogical mechanisms explaining this improvement can be understood from two synergistic aspects. From the media perspective, when students physically open a flap to find a discussion question, pull a tab to reveal hidden information, or attach illustration pieces using velcro, these kinesthetic experiences activate dual coding processes that strengthen memory and comprehension (Mayer, 2023; Kurniawan, 2025). Critically, the integration of PBL phases into these physical features offers a specific cognitive pathway toward the reorganization level of Barrett's Taxonomy the indicator that recorded the lowest initial score. The reorganization level requires students to classify, outline, summarize, and synthesize information beyond what is explicitly stated in the text (Nurbaya, 2019). For Grade III students at the concrete operational stage, this cognitive demand is particularly challenging when approached through abstract verbal instruction alone. The Pull-Tab mechanism addresses this by requiring students to physically reveal sequenced information in a controlled order, thereby externalizing the cognitive process of sequencing and structuring textual information a direct analog to the mental reorganization process itself. Similarly, the Flip-the-Flap mechanism in the investigation phase presents discussion questions that cannot be answered through literal reading alone, compelling students to synthesize information from multiple parts of the story before lifting the flap to verify their reasoning. This physical act of revelation serves as immediate formative feedback, reinforcing the reorganization process at a concrete, manipulative level that is developmentally appropriate for 8-to-9-year-old learners (Yunaini & Winingsih, 2022; Hayat et al., 2024). From the PBL perspective, the investigation process through the 'Detective Project' LKPD trains students to identify problems, formulate hypotheses, and evaluate solutions activities that directly activate critical thinking as the foundation of higher-order reading comprehension (Jaganathan et al., 2024;

Syamsudin, 2020). Together, these two mechanisms create a scaffolded cognitive progression: the physical interaction concretizes the abstract reorganization process, while the PBL structure provides the purposeful context within which that reorganization becomes meaningful.

A comparison with prior research reinforces the significance of these findings. Triani & Nuryanto (2024) developed a PBL-based Pop-Up Book for Grade IV elementary students with N-Gain in the effective category, but focused on general learning outcomes rather than specifically on reading comprehension. Bahari et al. (2026) reported an N-Gain of 0.55 in a QR-code-based contextual learning module comparable to the findings of this study, but in a digital learning context. Pramesti & Cahyaningtyas (2025) demonstrated the effectiveness of illustrated storybooks for improving text comprehension ability, but without PBL integration. Lusiana et al. (2026) recorded an N-Gain of 0.71 in Google Sites-based media, but requiring internet infrastructure not always available.

The N-Gain value of this study (0.56) falls within a range comparable to several digital media-based studies, such as Bahari et al. (2026) with N-Gain 0.55 and Lusiana et al. (2026) with N-Gain 0.71. This comparison is descriptive in nature and is not intended to imply that print media is superior to digital media. The N-Gain value obtained demonstrates that this media produces improvement within the range reported by other studies, making it suitable for further examination through explicitly designed comparative studies. The novelty of this study lies in its position as a learning medium that structurally integrates PBL into the physical mechanisms of a printed storybook, achieving significant improvement without relying on digital infrastructure, while comprehensively measuring all five reading comprehension indicators based on Barrett's Taxonomy demonstrating that the effectiveness of instructional media is determined more by the appropriateness of its design to students' cognitive characteristics and the pedagogical principles of the instructional model applied, than by the level of technological sophistication employed.

Conclusion

This study successfully developed a PBL-based interactive storybook entitled "Misteri Bola Kertas" using the 4D model, proven to be feasible, practical, and effective. Product feasibility was confirmed through an expert validation average of 81.53% (feasible). Practicality was confirmed through student responses of 93.75% and teacher responses of 88.5% (both Very Practical). Effectiveness was statistically demonstrated through an increase in the mean score from 67.81 to 83.65 (N-Gain 0.56, moderate category) and a highly significant Paired Sample T-test result (Sig. < 0.001). These findings demonstrate that the structural integration of physical interactive storybook features and PBL phases represents a coherent and further-developable pedagogical mechanism. Practically, this medium offers a learning alternative that does not depend on digital infrastructure relevant for the context of elementary schools in Indonesia still in the process of strengthening teachers' digital competence.

Recommendation

Based on the research findings, several recommendations are proposed. For educational practitioners, this interactive storybook can serve as a reference for designing instructional media that integrates the PBL model without requiring digital devices. Teachers are advised to utilize the Flip-the-Flap and Pull-Tab features as structured group discussion triggers. For future product developers, it is important to consider adding a comparison class (quasi-experimental design) to strengthen causal claims of effectiveness. Replication in

schools with different characteristics in terms of facilities, teacher competence, and student backgrounds is highly recommended to test the generalizability of the product. Furthermore, longitudinal research is needed to evaluate whether the improvement in reading comprehension ability achieved in a single session can be sustained and developed into a stable skill.

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