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Literature Review 2020-2025: Innovation of Pop-Up Book Employing Problem Based Learning to Improve Students' Learning Outcomes and Critical Thinking Skills

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A B S T R A C T

The rapid development of digital learning media necessitates that educators implement engaging and effective instructional strategies. One innovative tool gaining significant attention is the pop-up book. This study aims to evaluate the enhancement of students' learning outcomes and critical thinking skills through the integration of pop-up books within a Problem Based Learning (PBL) approach. The research methodology employed is a Systematic Literature Review (SLR) covering publications from 2020 to 2025. A total of 500 articles indexed in Google Scholar were analyzed using bibliometric mapping via Publish or Perish and VOSviewer, with twenty five key articles selected for in-depth examination. The findings indicate that contemporary research focuses heavily on the synergy between interactive learning media and instructional models, with the combination of pop-up books and PBL emerging as a frequently explored variable. Evidence suggests that employing pop-up books within a PBL framework effectively improves both academic performance and critical thinking abilities. Consequently, this integration serves as a practical and innovative teaching strategy to meet the demands of modern education.

1. Introduction

Education is fundamentally a deliberate endeavor aimed at fostering an interactive learning ecosystem that empowers students to cultivate their inherent potential (Pristiwanti et al., 2022). Within the framework of the Independent Curriculum, the educational paradigm transcends mere knowledge dissemination, prioritizing character formation and the acquisition of competencies aligned with 21st-century demands (Fitri et al., 2024; Elmi & Librianty, 2023). A primary objective among these competencies is the mastery of critical thinking, which equips learners with

the capacity to scrutinize information, appraise arguments, and autonomously navigate multifaceted problem-solving scenarios (Ma'rifah & Mawardi, 2022; Arrieta, 2021).

Despite these objectives, the practical implementation at the elementary school level continues to face significant hurdles in fostering critical thinking and achieving optimal learning outcomes. Pedagogical practices often remain conventional and teacher-centered, leading to student passivity and diminished engagement (Rahmayati et al., 2023). This issue is further compounded by the insufficient utilization of interactive learning media that resonates with the characteristics of digital natives, thereby hindering students' ability to construct deep conceptual understanding (Rama & Antara, 2022). Furthermore, in the absence of adequate visual and auditory stimulation, abstract concepts remain challenging for elementary students, who according to Piagetian theory are still functioning within the concrete operational stage of cognitive development.

To bridge this gap, a strategic integration of innovative instructional media and appropriate pedagogical models is essential. The implementation of Digital Pop-Up Books emerges as a potent solution, offering a multisensory experience through 3D elements, text, imagery, audio, and video that stimulate students' imagination and learning interest (Rosyada et al., 2025; Rahmadhani et al., 2025). Rather than serving merely as a visual aid, this medium acts as a pivotal instrument for elucidating complex scientific concepts through engaging animations (Akina et al., 2023; Sulistiowati & Wiarsih, 2021).

However, the efficacy of digital media is maximized only when supported by a learning model that fosters independent thinking. The Problem-Based Learning (PBL) model aligns seamlessly with this objective by immersing students in real-world problems that necessitate collaboration and critical analysis (Ariyani & Kristin, 2021; Kurniasih, 2014). Through the five systematic stages of PBL ranging from problem orientation to evaluation—students are empowered to become active problem solvers, which ultimately enhances both cognitive and affective learning outcomes (Rusman, 2015; Kristiana & Radia, 2021; Wahyuni et al., 2021).

While previous studies have examined the effectiveness of Pop-Up Books and the PBL model in isolation, research specifically integrating Digital Pop-Up Books into the PBL syntax remains scarce, particularly within the context of the Independent Curriculum in elementary education. The novelty of this research lies in the synergy between dynamic digital visual media and the inquiry-based steps of PBL to create a meaningful learning experience. Consequently, this study aims to analyze the effectiveness of utilizing Digital Pop-Up Books based on the PBL model in improving the critical thinking skills and learning outcomes of elementary school students.

2. Methodology

This study employs a systematic literature review (SLR) integrated with bibliometric analysis to delineate research trends and synthesize empirical evidence

from extant studies (Silber-Varod et al., 2019). The methodology utilizes two specialized computational tools: Publish or Perish for robust article retrieval and VOSviewer for the bibliometric visualization of metadata. Data were harvested from the Google Scholar database, covering a five-year publication window from 2020 to 2025. The search strategy employed a combination of keywords, including "Pop-Up Book," "Problem-Based Learning," "Learning Outcomes," and "Critical Thinking." The initial search was capped at 500 records published in both Indonesian and English.

The selection process followed a rigorous multi-stage screening. Out of the initial 500 records, 300 were excluded during the preliminary screening for lack of relevance to the core keywords. Subsequent title and abstract screening identified 50 articles meeting the inclusion criteria. During the eligibility phase, 10 documents were excluded as they were unpublished theses or dissertations, ensuring the analysis focused solely on peer-reviewed literature. A further verification of 30 articles led to the exclusion of 5 studies that did not specifically focus on the integration of PBL with Pop-Up Book innovations. Consequently, a final corpus of 25 high-quality articles was synthesized for the bibliometric and thematic analysis.

For the analytical phase, bibliographic metadata (author names, publication years, and keywords) were exported in RIS and CSV formats. Co-occurrence analysis was performed using VOSviewer to map the conceptual landscape and interconnections between the primary variables. Furthermore, a thematic content analysis was conducted to evaluate the effectiveness of this pedagogical medium. This dual-methodological approach ensures a comprehensive interpretation of how digital pop-up books facilitate cognitive development within primary education. The systematic screening workflow is visualized in Figure 1.

The systematic literature selection process is visually detailed in Figure 1, adopting a structured, multi-stage screening approach. The flowchart illustrates the rigorous transition from the initial identification of 500 records to the final inclusion of 25 primary articles. The diagram explicitly delineates the justification for exclusion at each phase—ranging from keyword irrelevance and document type (e.g., unpublished theses or dissertations) to a lack of focus on the thematic integration of the PBL model with Pop-Up Book media. This procedural transparency ensures the integrity of the data collection process and confirms that the bibliometric and thematic analyses are predicated on high-quality, peer-reviewed sources.

The inaugural phase of the bibliometric analysis involved a comprehensive mapping of the literature distribution to evaluate the evolution of research interest within this specialized domain over the past five years. This temporal analysis is instrumental in identifying the trajectory of pedagogical innovations and the intensity of scholarly discourse surrounding interactive learning tools. By quantifying the academic output, this study identifies the momentum of research development and highlights periods of significant conceptual expansion. Based on the synthesized dataset, the distribution of research publications concerning PBL-based Pop-Up Book media from 2020 to 2025 is presented in Figure 2.

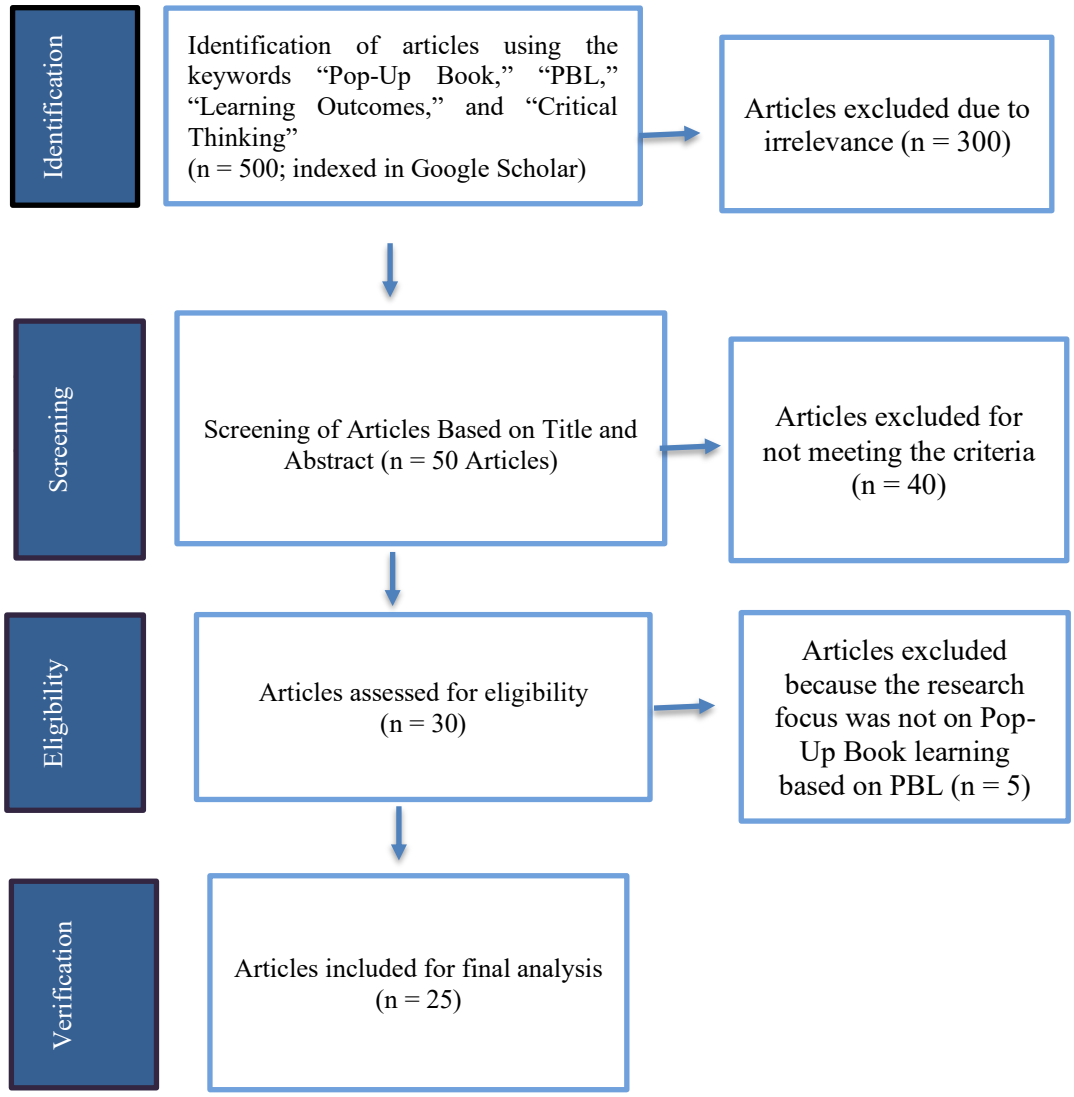

Figure 1. Flowchart of the Article Search Process

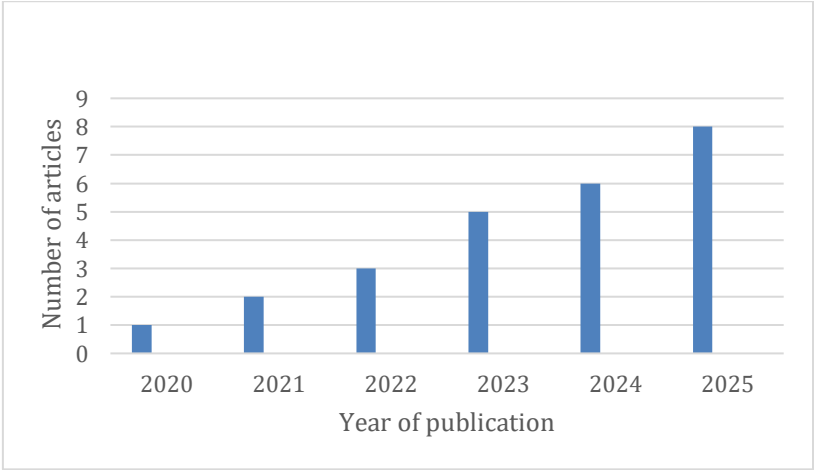

Figure 2. Publication Chart of Pop-Up Book Media Based on PBL Research

As illustrated in Figure 2, the longitudinal distribution of research concerning the implementation of PBL-based Pop-Up Book media from 2020 to 2025 exhibits a compelling upward trajectory. The data delineates a progressive trend, characterized by a steady accumulation of scholarly contributions that culminates in its zenith in 2025. This surge suggests that the convergence of interactive digital media and problem-based learning frameworks has moved to the forefront of contemporary educational discourse. This evolution is largely catalyzed by the imperative to synchronize pedagogical practices with the rigorous demands of 21st-century digital competencies and the flexibility required by the Independent Curriculum.

Beyond the temporal evolution of the literature, identifying the institutional affiliations that have shaped this academic landscape is equally vital. Such analysis provides profound insights into the primary academic centers and universities spearheading the development of PBL-based Pop-Up Book innovations. By mapping these affiliations, the study identifies the "intellectual hubs" of productivity and underscores the strategic role of higher education institutions in advancing sophisticated pedagogical tools. The distribution of research output across the leading contributing universities is visualized in Figure 3.

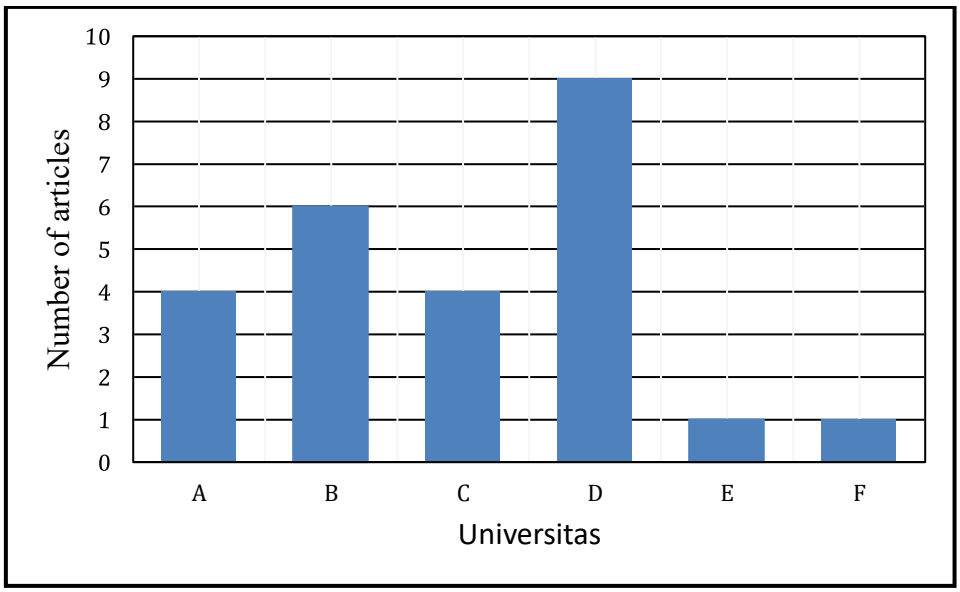

Figure 3. Contribution of Universities and Schools to Pop-Up Book Media Research Based on PBL

Based on the bibliometric data, Semarang State University emerges as the most prolific institution, demonstrating a substantial lead over other universities in terms of publication volume. This institutional dominance suggests a robust commitment and a highly developed research ecosystem specifically dedicated to the integration of interactive media within student-centered learning frameworks. Such high productivity not only positions Semarang State University as a primary scholarly reference but also as a catalyst, encouraging other academic institutions to modernize their instructional methodologies. Ultimately, this institutional mapping

confirms that the innovation of PBL-based Pop-Up Books has secured a firm foothold within the strategic research agendas of Indonesia's leading educational universities. This trend underscores a broader institutional shift toward digitizing pedagogical tools to meet evolving academic standards. A comprehensive breakdown of the contributing institutions and their respective article counts is presented in Table 1.

Table 1. Description of the Chart: Universities/Schools of Article Origin

Universitas/School	Code
PGRI University Semarang	A
Indonesia University of Education	B
Sebelas April University	C
Semarang State University	D
PGRI University Madiun	E
Nahdlatul Ulama University	F

To further evaluate the academic influence and quality of the selected literature, an analysis of citation metrics was conducted to identify the most impactful studies in this domain. This stage is crucial for pinpointing the seminal works that have significantly shaped the discourse on PBL-based Pop-Up Book innovations. From the twenty five articles on Pop-Up Book media based on PBL, five articles with the highest citation counts were selected. The details are provided in Table 2.

Table 2. Research on Competencies Measured by Pop-Up Book Media Based on PBL

No	Article title	Author	Citation
1	The Effect of PBL Model Assisted by Pop-Up Book Media on the Critical Thinking Skills of 5th Grade Students at SD Negeri Brumbung	Rahmayati et al., 2023	11
2	Development of Pop-Up Book Learning Media on the Solar System Material Based on PBL to Improve Critical Thinking Skills	Nurkumala et al., 2024	10
3	Implementation of a Pop-Up Book-Based PBL Model in Civics Learning at Elementary School	Nugraheni et al., 2023	4
4	Effectiveness of Implementing a PBL Model Assisted by Pop-Up Book in Developing Students' Critical Thinking Skills on Spatial Geometry at SD Negeri Gugus Ki Hajar Dewantara Pemalang	Rahmawati & Noening, 2024	3
5	Improving Student Learning Outcomes Using a PBL Model Based on Pop-Up Media on Spatial Geometry Material for 4th Grade Students at SD Al Azam Semarang	Pratama & Prayito, 2024	2

Among these highly cited works, the study by Rahmayati et al. (2023), titled 'The Effect of PBL Model Assisted by Pop-Up Book Media on the Critical Thinking Skills of 5th Grade Students at SD Negeri Brumbung,' stands out as a significant contribution. This research provides empirical evidence on how the synergy between problem-based learning and interactive visual media can specifically

catalyze the development of higher-order thinking skills in primary school students. The high citation frequency of this article underscores its role as a fundamental reference for practitioners and researchers aiming to implement effective, student-centered instructional tools in the classroom.

3. Results and Discussion

Publication Trends and Institutional Landscape: A Critical Analysis

The bibliometric analysis reveals a significant and sustained expansion in the research landscape concerning PBL-based Pop-Up Book media. As depicted in Figure 2, the scholarly output from 2020 to 2025 exhibits a consistent annual growth, indicating that this field has transitioned from a niche pedagogical experiment into a mainstream instructional discourse. The data demonstrates a clear upward trajectory, with the number of publications increasing incrementally each year. This steady rise can be critically interpreted as a response to the global shift toward digital-based educational tools, which was significantly accelerated by the post-pandemic necessity for resilient and engaging learning media. Between 2020 and 2022, the research primarily focused on the feasibility of digital media. However, from 2023 to 2025, there is a noticeable shift toward more complex integrations—specifically combining the multisensory appeal of digital pop-up books with the inquiry-based syntax of Problem-Based Learning (PBL). The peak in 2025 signifies that this integration is now regarded as a mature solution for addressing the demands of the Independent Curriculum, which prioritizes student-centered learning and critical thinking. This trend suggests that the academic community increasingly views the synergy of visual technology and problem-solving models as a prerequisite for effective 21st-century primary education.

The institutional mapping (see Figure 3 and Table 1) further elucidates the "intellectual geography" of this research domain. Semarang State University stands out as the most prolific contributor, maintaining a dominant lead in publication volume. This dominance is not merely numerical but reflects a robust institutional ecosystem that prioritizes the modernization of teacher education. The concentration of research within leading educational universities in Indonesia indicates a strategic top-down effort to bridge the gap between theoretical pedagogical models and practical classroom applications. These institutions act as innovation hubs; their consistent output suggests that the development of PBL-based Pop-Up Books is a central pillar of their research agendas. This institutional commitment is vital, as it ensures that the innovations developed are not isolated studies but are part of a broader, evidence-based movement to enhance the quality of primary school instruction nationwide.

Orientation of Pop-Up Book Innovation Based on PBL to Improve Students' Learning Outcomes and Critical Thinking Skills

Based on the synthesis of the twenty five articles reviewed, five specific studies were identified as having a primary orientation toward developing or implementing

Pop-Up Book innovations within a PBL framework. As summarized in Table 3, the research landscapes are dominated by three methodological approaches: Research and Development (R&D), Experimental Research, and Classroom Action Research (CAR). However, a deeper critical analysis suggests that the choice of these methods reflects different strategic goals in addressing pedagogical challenges in Science (IPAS) education.

Table 3. Research Methods in Pop-Up Book-Based PBL Innovation to Improve Students' Learning Outcomes and Critical Thinking Skills

Research Methods	Author
Research and Development (R&D)	Nurkumala et al., 2024
Experimental Research	Rahmayati et al., 2023
Experimental Research	Rosyada et al., 2025
Classroom Action Research	Rahmadhani et al., 2025

The prevalence of the Research and Development (R&D) method, as demonstrated by Nurkumala et al. (2024), indicates that the current research priority is still heavily focused on the validity and practicality of the media itself. From a conceptual standpoint, this suggests a "design-centric" gap where researchers are primarily concerned with ensuring that the physical or digital layers of Pop-Up Books can effectively host the complex syntax of the PBL model. While these studies confirm that the media is "fit for purpose," they often stop short of exploring the cognitive mechanisms that occur during student-media interaction.

In contrast, Experimental Research (e.g., Rahmayati et al., 2023; Rosyada et al., 2025) provides a more rigorous quantitative verification of efficacy. These studies consistently report significant improvements in critical thinking skills, yet they often treat the PBL-Pop-Up Book integration as a "black box." There is a notable lack of discussion regarding which specific phase of PBL whether it is the Problem Orientation or the Analysis and Evaluation stage is most enhanced by the visual-spatial nature of the Pop-Up Book.

A critical point of discussion arises from the observation that these innovations are frequently more successful at improving learning outcomes (cognitive scores) than critical thinking skills. Conceptually, this can be attributed to the "Visual Scaffolding" effect. Pop-Up Books provide immediate, concrete representations of abstract Science concepts, which facilitates rapid information encoding and retention (learning outcomes). However, fostering critical thinking requires the media to do more than just "show" information; it must "challenge" the student. The analysis suggests a theoretical gap where the Pop-Up Books reviewed are predominantly used as illustrative tools rather than inquiry-driven tools. Future orientations should focus on designing "Problem-Based Pop-Up Books" that hide certain information or present visual anomalies that require students to investigate, thereby aligning more closely with the higher-order thinking objectives of the PBL model.

The concentration of these methods within Science (IPAS) material (as seen in Table 3) is not coincidental. Science requires the visualization of phenomena that

are often too small, too large, or too abstract for the naked eye. The integration of PBL provides the "why" (the problem to solve), while the Pop-Up Book provides the "how" (the visual evidence). Nevertheless, the current literature's heavy reliance on Classroom Action Research (e.g., Rahmadhani et al., 2025) highlights a "localization bias." While CAR is excellent for solving immediate classroom issues, its findings are difficult to generalize. This underscores the need for more large-scale, multi-site experimental studies to confirm if the PBL Pop-Up Book synergy remains effective across diverse demographic and socioeconomic student backgrounds.

Analysis of Pop-Up Book Innovation Based on PBL to Improve Students' Learning Outcomes and Critical Thinking Skills

Based on the systematic review of twenty five selected articles. The data reveals a slight predominance of studies focusing on learning outcomes (n=15) compared to those targeting critical thinking skills (n=10). While both domains show positive improvements, a deeper critical analysis is required to understand why these innovations impact students differently. the distribution of students' cognitive domain abilities targeted by Pop-Up Book-based PBL innovations is illustrated in the pie chart in Figure 4.

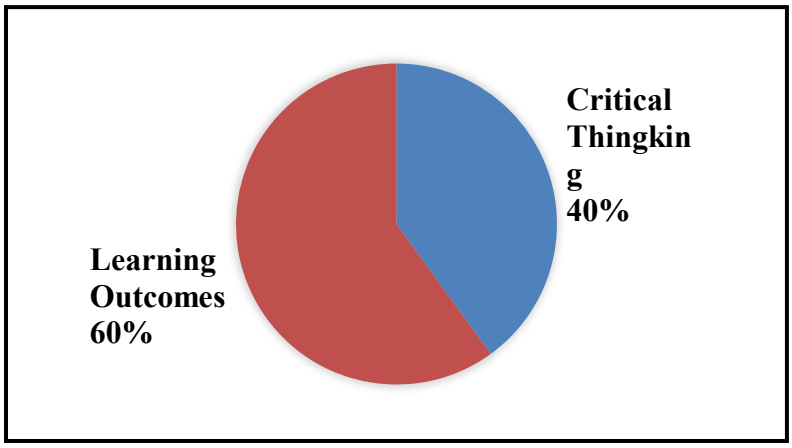

Figure 4. Students' Cognitive Domain Abilities

The disproportionate emphasis on enhancing general learning outcomes as evidenced by the works of Hayati et al. (2025) and Nugraheni et al. (2023) underscores the potent capacity of Pop-Up Book media to optimize the mechanics of information encoding. From a conceptual standpoint, these interactive tools act as a 'Visual Scaffolding' mechanism that strategically mitigates cognitive load during complex inquiry processes. Drawing upon Dual Coding Theory, the efficacy of this medium lies in its ability to synchronize the processing of verbal-instructional cues from the PBL syntax with the vivid visual-spatial stimuli of 3D elements. This simultaneous dual-channel engagement effectively bridges the gap between abstract scientific or mathematical constructs and concrete mental representations, thereby accelerating information retention and translating into superior academic performance. Given the historical scarcity of immersive media in traditional classrooms, the strategic integration of PBL-based Pop-Up Books

represents a high-impact intervention that yields immediate and measurable gains in students' foundational learning outcomes.

Conversely, the scholarship led by Rahmayati et al. (2023) and Nurkumala et al. (2024) ventures into the more intricate domain of critical thinking, yet the relative scarcity of such studies exposes a significant conceptual research gap. While the empirical evidence suggests that these interventions are effective, critical thinking necessitates a cognitive transition that transcends mere comprehension, demanding a higher-order capacity for systematic analysis and evaluation.

Theoretically, within this pedagogical synergy, the PBL model establishes the 'inquiry framework,' while the Pop-Up Book functions as the 'visual evidence.' However, the progression from perceiving a three-dimensional model to executing complex problem analysis represents a sophisticated cognitive leap that remains inadequately explored. Current literature frequently overlooks the specific mechanism of action the precise way in which a tactile-visual medium triggers the metacognitive shifts essential for critical inquiry. This suggests that while Pop-Up Books excel at 'visualizing' knowledge, there is a pressing need for future research to explore designs that 'challenge' knowledge. By evolving from illustrative tools into catalysts for cognitive conflict, these media can more authentically fulfill the higher-order thinking objectives inherent in the PBL philosophy.

It is imperative to acknowledge that the conclusions drawn from the data in Figure 4 are constrained by several inherent limitations. The relatively modest sample size (n=25) and the pronounced geographical concentration of these studies predominantly situated within the Indonesian educational landscape restrict the broader generalizability of the findings across diverse cultural and systemic contexts. Furthermore, the exclusive reliance on Google Scholar as the primary data source may have inadvertently excluded high-impact global studies indexed in other specialized databases, which might utilize alternative cognitive measurement frameworks or different pedagogical paradigms.

The observed prevalence of 'learning outcomes' as a primary research target may also indicate a 'low-hanging fruit' bias. This suggests a tendency in current scholarship to prioritize immediate, quantifiable gains over the more arduous and longitudinal assessment of complex critical thinking skills. Consequently, this study identifies a critical necessity for future research to expand its database inclusion and adopt longitudinal methodologies. Such an expansion is vital to validate whether the synergy between PBL and Pop-Up Book media can consistently catalyze deep cognitive shifts and remain robust across varying demographic and socio-economic strata.

Learning Content Integration: A Critical Perspective on Subject Matter Suitability

Based on the systematic analysis of the selected literature, The data reveals a strategic concentration in three primary disciplinary domains: Science (IPAS), Civics Education, and Mathematics. A critical examination of this distribution

suggests that the selection of subject matter is not merely incidental but is deeply rooted in the inherent characteristics of the content and its alignment with the visual-spatial affordances of Pop-Up media. The thematic distribution of learning materials utilized in Pop-Up Book-based PBL innovations is synthesized in Table 4.

Table 4. Learning Content Used in Pop-Up Book-Based PBL Innovations

Authors	Material
Rahmayati et al., (2023), Rosyada et al., (2025), Rahmadhani et al., (2025) and Nurkumala et al., (2024).	IPAS
Nugraheni et al., (2023) and Astria & Aeni, (2025).	Civics Education
Hayati et al., (2025), Pratama & Prayito, (2024), and Rahmawati & Noening, (2024)	Mathematics

The predominance of Science (IPAS) as the primary subject matter across four significant studies underscores a fundamental pedagogical synergy between the discipline's requirements and the media's capabilities. Science education inherently necessitates the visualization of complex, abstract, or microscopic phenomena that often elude the immediate sensory perception of primary-level students. As highlighted by Muna et al. (2024), the three-dimensional interactivity of Pop-Up Books serves as a vital bridge, facilitating the transition from abstract conceptualization to concrete representation and strategically mitigating cognitive barriers.

Furthermore, the alignment with Problem-Based Learning (PBL) is exceptionally robust within the scientific domain; the model's emphasis on investigating 'real-world phenomena' finds its most seamless application in the exploration of biological, physical, and environmental challenges. This integration transcends mere engagement; it actively fosters sophisticated cognitive processing by providing students with a tactile-visual platform to manipulate and analyze data. Ultimately, the use of Pop-Up Books in Science not only heightens learner enthusiasm but also functions as a cognitive scaffold that clarifies the intricate causal relationships inherent in scientific inquiry.

The extension of this innovation into Civics Education and Mathematics further underscores the multifaceted versatility of PBL-integrated Pop-Up Books. In the context of Civics Education, the medium serves as a critical bridge for contextualizing abstract societal values and civic obligations, translating them into relatable, narrative-driven scenarios that resonate with young learners. Conversely, in Mathematics, the three-dimensional elements of the Pop-Up Book introduce a vital tactile dimension to geometric and logical constructs, thereby reinforcing the inquiry-based framework of the PBL model.

Despite these diverse applications, a significant critical gap persists within the existing literature concerning the comparative efficacy of this medium across differing academic disciplines. While its effectiveness in Science is well-

documented, there remains a dearth of scholarly discourse on whether these visual-spatial mechanisms are equally potent when applied to the non-visual, abstract logic of advanced Mathematics or the normative, value-based discussions inherent in Civics. This oversight suggests that future research must move beyond singular-subject validation to explore how the cognitive affordances of Pop-Up Books vary when confronted with the distinct epistemological demands of various curricular domains.

The prevailing emphasis on Science suggests that researchers predominantly prioritize subjects with inherent 'visual potential,' where the media's affordances are most intuitive. However, this concentration reveals a significant missed opportunity to evaluate the impact of such media on linguistic literacy or the arts within a PBL framework. While the strategic use of Pop-Up Books to catalyze student enthusiasm and curiosity is well-documented, the medium must transcend its current status as a 'supplementary novelty.

To achieve this, future scholarship must rigorously investigate how these tools can be meticulously tailored to meet the unique cognitive demands of diverse academic disciplines. This thematic analysis confirms that while the Pop-Up Book serves as a formidable catalyst for Science (IPAS) learning outcomes, its broader potential across the elementary curriculum remains a fertile ground for more diverse pedagogical exploration. Ultimately, transitioning from illustrative use to a more integrated cognitive tool will be essential in validating the universal efficacy of PBL-based Pop-Up Books in fostering holistic student development.

4. Conclusion

This systematic review of twenty five selected articles provides a critical synthesis of the integration of Problem-Based Learning (PBL) with Pop-Up Book media to enhance students' learning outcomes and critical thinking skills. The findings reveal a significant surge in research interest post-2022, with Semarang State University emerging as the primary institutional hub for this innovation. Methodologically, the dominance of Research and Development (R&D) and Experimental studies underscores a strong institutional commitment to validating the practicality and effectiveness of this media, particularly within the domain of Science (IPAS).

The analysis highlights that while PBL-based Pop-Up Books are exceptionally potent in improving learning outcomes, their impact on critical thinking skills requires further conceptual refinement. Drawing on Dual Coding Theory, this study concludes that the media’s primary strength lies in its "visual scaffolding" capability, which reduces cognitive load and accelerates information retention. However, the transition from visual perception to higher-order analytical reasoning remains a "cognitive leap" that is not yet fully explored in current literature. Furthermore, the heavy concentration of research in Science reveals a missed opportunity to explore the media's versatility in non-visual subjects like language or social ethics.

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