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A hands-on STEAM picture book model to enhance critical thinking and integrated science learning interest of elementary school students

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Abstract: Critical Thinking and Science Learning Interest among third-grade elementary students are still low due to conventional learning methods that lack active engagement. This research aims to develop and test the feasibility of the Picture Story Book Media with a STEAM approach to enhance both of these dependent variables, focusing on the topic of Unique Relationships in Living Things (Symbiosis). Using the ADDIE Research and Development (R&D) model, the product was tested and achieved Very Valid and Very Practical criteria, confirming its implementation feasibility. The effectiveness results were significant. The increase in Learning Interest was categorized as Very High, particularly in the Active Involvement indicator (Slameto), as the narrative successfully triggered enjoyable hands-on action. Critical Thinking improvement was also categorized as High, specifically in the Interpretation and Analysis dimensions (Facione). This was driven by the Engineering challenge to design symbiosis models, which compelled students to use critical logic. This media successfully integrates Story and Art with Hands-On Activities to transform abstract Symbiosis concepts into solution-based investigations. This product effectively strengthens both students' Critical Thinking and Learning Interest.

Keywords: Picture Story Book; STEAM; Hands-On; Critical Thinking; Learning Interest

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INTRODUCTION

The Indonesian Integrated Science and Social Studies subject, introduced under the Merdeka Curriculum, holds a vital position in elementary education. Science and Social subjects serve as a foundational platform for students to develop essential 21st-century skills, notably the ability to think critically, solve problems, and connect scientific concepts with real-world social phenomena (Harefa et al., 2023; Patonah et al., 2020). Mastering topics like Unique Relationships in Living Things (Symbiosis) requires more than memorization; it demands logical analysis and deep understanding.

However, the successful execution of this curriculum often faces significant challenges at the implementation level. Conventional teaching methods, primarily relying on lectures and textbooks, fail to transform complex Science and Social Studies content into an engaging learning experience. This passive approach discourages exploration and discussion, reducing the learning environment to a mere transfer of facts rather than a dynamic space for inquiry.

Consequently, this lack of stimulating instruction leads to two major, interconnected issues observed in the classroom: the low development of Critical Thinking Skills and stagnant Learning Interest among students (Ariawan & Suartama, 2024; Kasanah et al., 2024). Specifically, observations in Grade III elementary schools indicate that students struggle to move beyond simple recall, finding it difficult to interpret information, analyze relationships (Facione's dimensions), or evaluate outcomes of scientific concepts.

This deficiency is particularly pronounced among Grade III students, given their specific cognitive characteristics. According to Bruner's theory of cognitive development, children in this phase are transitioning into the iconic mode of representation, meaning their understanding is heavily reliant on visual imagery and concrete manipulation (Dewi et al., 2018). Abstract science subject concepts, such as the mechanisms of mutualism or parasitism, remain opaque unless translated into tangible, observable, and engaging learning experiences.

To bridge this critical gap, the implementation of appropriate learning media is indispensable. The Picture Story Book is proposed as the ideal core medium. Its inherent visual richness (Art) and compelling narrative structure immediately capture the students' imagination, effectively lowering the affective filter and fostering Learning Interest as defined by Slameto, particularly the aspects of joy and attraction (Hendrawijaya, 2022). Nevertheless, relying solely on visual narratives is insufficient to develop higher-order cognitive abilities. Therefore, the storybook must be paired with an active, systematic pedagogical approach. The Science, Technology, Engineering, Art, and Mathematics (STEAM) framework offers the holistic structure required, as it integrates content knowledge with real-world challenges (Engineering) and encourages collaborative problem-solving (Yulaikah et al., 2022).

The synthesis of these elements forms the STEAM Hands-On Picture Story Book Model. The story acts as the motivator and contextualizer, presenting a problem or relationship (like the symbiotic relationship between the crocodile and the bird in the provided content). This narrative then triggers an Engineering challenge by designing a model to classify and score the "benefit or not" of symbiosis, transforming passive reading into an active investigation and strengthening the Active Involvement indicator of interest (Rhodes et al., 2020).

In essence, this model reverts the story's charm to facilitate the crucial hands-on activities required for deep learning. By engaging in tangible design and analysis, students are systematically pushed to practice the Interpretation and Analysis dimensions of Critical Thinking (Facione), ultimately leading to verifiable intellectual growth. The primary aims are to: (1) determine the Validity of the developed media, (2) ascertain its Practicality in the learning process, and (3) measure its Effectiveness in significantly enhancing students' Critical Thinking Skills and Learning Interest in Science and Social Studies, thereby contributing a verified alternative solution to improving elementary education quality.

METHODS

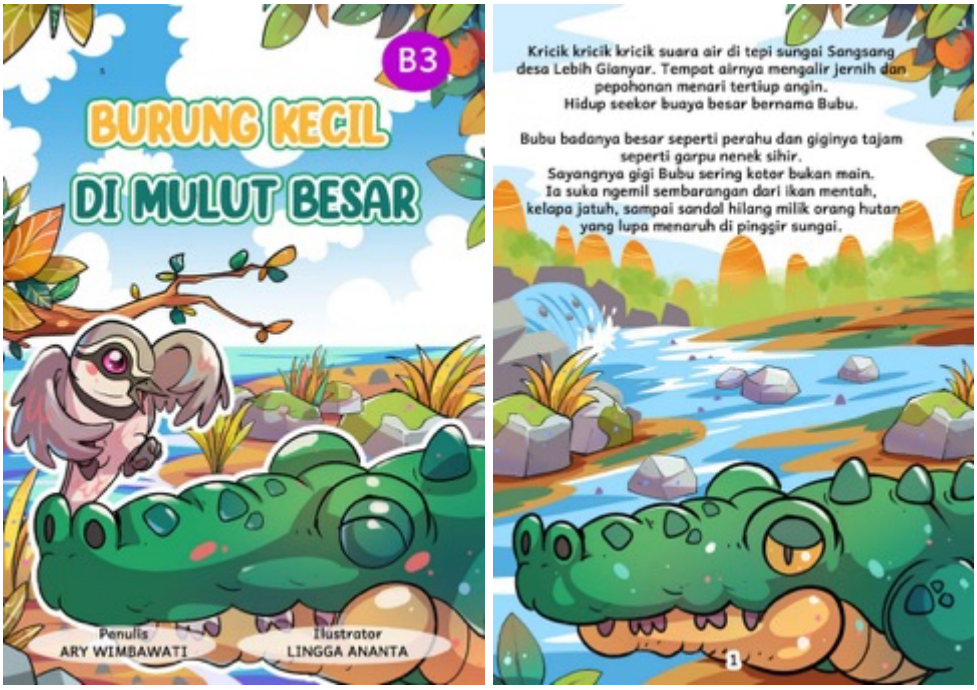
This study employed Research and Development (R&D) as its core method, aiming to produce an effective, practical, and validated learning medium. The design utilized the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) due to its systematic and iterative nature, ensuring continuous quality control throughout the product creation phase (Wicaksana et al., 2020). The procedural steps of the development included beside of Table 1: Analysis (identifying curriculum needs and student characteristics of Grade III Science and Social Studies, specifically the need to enhance Critical Thinking based on Facione's simplified dimensions), Design (developing instruments and drafting the Picture Story Book's narrative and STEAM Hands-On activities), Development (product creation and expert validation by

three specialized validators: material, media, and language experts), Implementation (conducting limited and main field trials), and Evaluation (analyzing all data gathered to finalize the product).

Table 1. Phase of ADDIE

Phase	Technical Procedure
1. Analysis	Needs analysis on Grade III Science and Social Studies curriculum, student characteristics, and identification of low Critical Thinking and Learning Interest.
2. Design	Drafting the Picture Story Book, creating STEAM Hands-On challenges (Symbiosis focus), and designing all research instruments (tests, questionnaires, and validation sheets).
3. Development	Media production and conducting expert validation (Material, Media, Language). Revision based on expert input.
4. Implementation	Conducting pre-test, treating the experimental group with the product, and conducting post-test (main field trial).
5. Evaluation	Analyzing Validity, Practicality, and Effectiveness data (using N-Gain and T-Test) to confirm product contribution.

The developed product, the STEAM Hands-On Picture Story Book, is designed as a physical medium to ensure tangible interaction for Grade III students. Its specifications include a finished size of A5, printed on full-color art paper, consisting of approximately 28 pages of narrative and visual content. The book's core content is the Science and Social Studies topic: "Unique Relationships in Living Things (Symbiosis)", contextualized through the story of Bubu (the Crocodile) and Pipi (the Bird), based on the provided material. Crucially, the book integrates specific STEAM Challenges linked to the story's conflict, such as the Engineering task of designing a simple model to classify and score the "gain/loss" (utilizing Math) of three types of symbiotic relationships, thereby embedding the hands-on activity directly into the learning sequence. Figure 1 shows the STEAM Hands-On Picture Story Book.



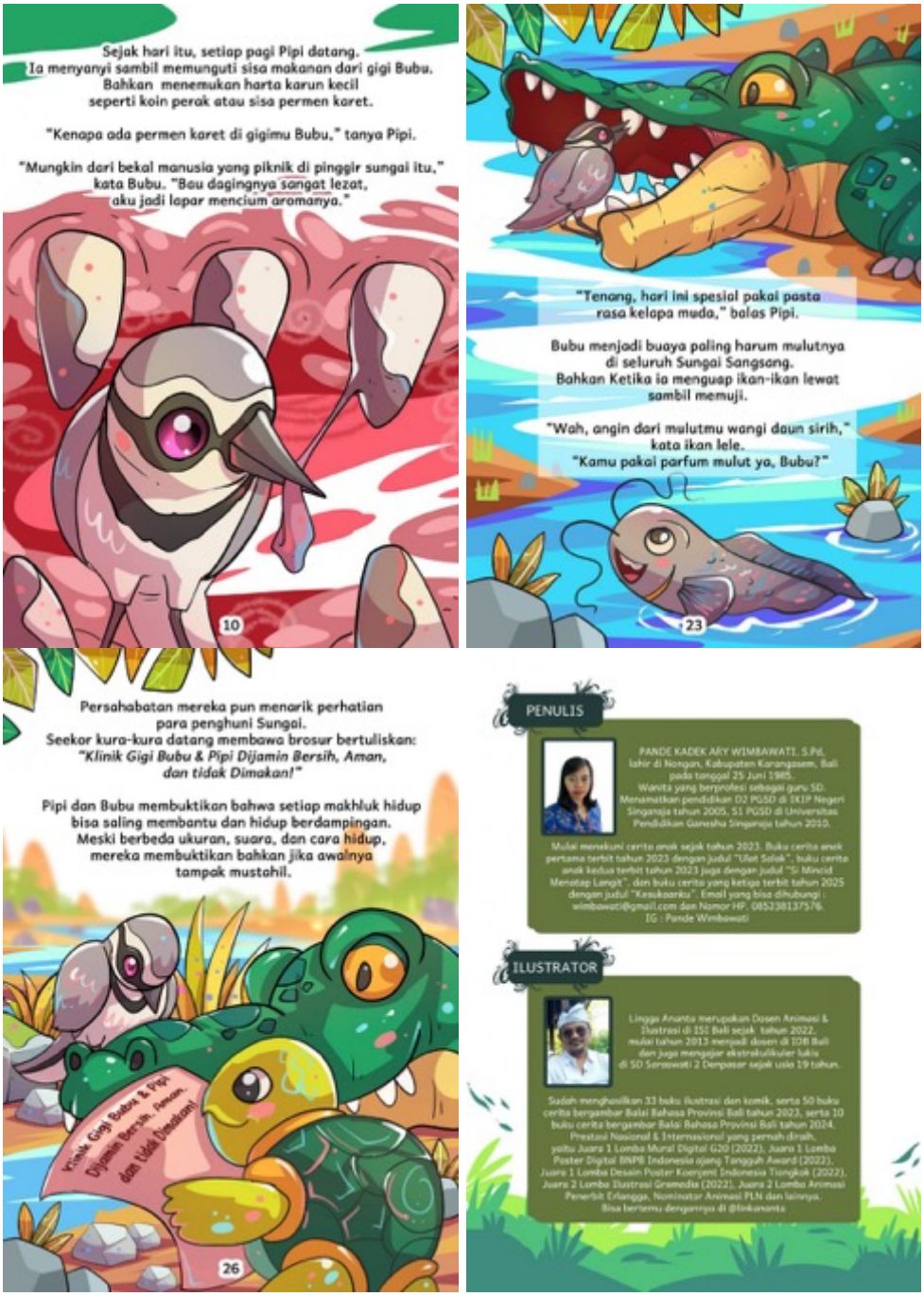


Figure 1. The STEAM hands-on picture story book

The research population comprised all Grade III students in Gugus II Bebandem, Bebandem District. Sampling utilized a Cluster Random Sampling technique, dividing students into an experimental group (using the STEAM Picture Story Book) and a control group (using conventional media). Data was collected using four types of instruments: (1) Validation Sheets (Likert scale) to assess the feasibility based on the three expert domains; (2) Practicality Questionnaires (percentage analysis) administered to teachers and students to gauge ease of use and appeal; (3) Critical Thinking Written Tests (multiple-choice, 20 items) focusing on Facione's simplified dimensions: Interpretation, Analysis, Inference, and Evaluation; and (4) Learning Interest Questionnaires (Likert scale) based on Slameto's indicators: Joy, Attraction, Acceptance, and Active Involvement.

Data analysis followed the three effectiveness criteria. Validation and Practicality data were analyzed using descriptive statistics and percentage calculations to determine eligibility thresholds. Effectiveness data for both Critical Thinking and Learning Interest were analyzed using a combination of inferential statistics (T-Test) to compare the experimental and control groups' post-test scores and N-Gain Score analysis to measure the actual magnitude of improvement. The N-Gain analysis was also applied per indicator (Analysis dimension for Critical Thinking, Active Involvement for Learning Interest) to identify specific areas where the STEAM Hands-On model provided the most impactful contribution.

RESULTS AND DISCUSSION

Product Validity Result

The validation process for the STEAM Hands-On Picture Story Book was executed during the Development phase of the ADDIE model, following the initial product draft. This crucial step was mandatory to ensure the product's quality, appropriateness, and scientific integrity before implementation. The validation aimed to assess three primary domains: material content, media design, and language clarity. Three domain-specific experts (validators) were recruited for this purpose: a Material Expert (Science Education Specialist), a Media Expert (Educational Technology/ Design Specialist), and a Language Expert (Bahasa Indonesia/ Elementary Education Specialist). Each validator was provided with the preliminary product draft and a validation instrument utilizing a five-point Likert scale to score specific assessment criteria. The experts provided quantitative ratings and necessary qualitative feedback for revision.

After the initial scoring, the validation data were analyzed using descriptive statistics, specifically calculating the average score across all criteria and converting it into a percentage of eligibility. The product was revised strictly based on the qualitative suggestions provided by the three validators by clarifying the wording of STEAM instructions, adjusting the font size for Grade III students, and ensuring the scientific accuracy of the Symbiosis classification. Only after the final revision, which addressed all comments, was the product declared ready for field testing. The quantitative findings from the expert validation demonstrate that the developed product possesses Very High Validity across all assessed domains, confirming its scientific and pedagogical feasibility. The aggregated results are presented in Table 2, showing the mean scores and the corresponding eligibility percentage for each validation aspect.

Table 2. Average scores for self-efficacy and critical thinking (pre-test and post-test)

Validation Aspect	Average Expert Score (out of 5.00)	Percentage (%)	Validity Criteria
Material Validity (Science and Social Studies Content & STEAM Integration)	4.6	92.00%	Very Valid
Media Validity (Design, Layout, and Visual Appeal)	4.55	91.00%	Very Valid
Language Validity (Clarity, Phrasing, and Readability)	4.7	94.00%	Very Valid
Overall Average	**4.62**	**92.33%**	**Very Valid**

The high validation scores underscore the quality of the media. The highest score was achieved in the Language Validity domain (94.00%), assuring that the narrative is highly readable and appropriate for the cognitive level of Grade III students. Crucially, the Material Validity score of 92.00% confirms that the integration of the STEAM Hands-On activities for the

Symbiosis topic is scientifically accurate and pedagogically sound for fostering Critical Thinking. Based on these results, the STEAM Hands-On Picture Story Book was deemed suitable and highly appropriate for use in the implementation phase without needing any major adjustments.

Product Practicality Result

The assessment of product practicality was conducted immediately following the expert validation and the necessary revisions, primarily during the Implementation phase of the ADDIE model. Practicality aims to determine the extent to which the STEAM Hands-On Picture Story Book is feasible, easy to use, and appealing when implemented in actual classroom learning. The measurement involved two distinct groups of respondents: the practicing teachers and the Grade III students who directly utilized the media during the trial period. Data were collected using specific practicality questionnaires employing a Likert scale format, which were then converted into percentage scores reflecting ease of use and appeal.

The overall results demonstrated that the media achieved Very High Practicality based on the criteria set for Research and Development products. This confirms that the integrated model is highly suitable for sustained use in Grade III SCIENCE AND SOCIAL STUDIES learning, fulfilling the requirements for effective learning media. Detailed findings from both teacher and student questionnaires are presented in Tables 3 and 4, respectively, which illustrate the product's strong acceptance in the field.

Practicality Results Based on Teacher Response

Teacher feedback focused primarily on the usability and efficiency of the media in supporting science and social studies instruction. The results confirmed that the integrated story-based STEAM activities aligned well with the *Merdeka Curriculum* and the time allocation for the Symbiosis topic.

Table 3. Summary of product practicality based on teacher response

Practicality Aspect	Average Expert Score (out of 5.00)	Percentage (%)	Practicality Criteria
Ease of Use (Clarity of STEAM Instructions)	4.75	95.00%	Very Practical
Time Efficiency (Alignment with Lesson Plan)	4.6	92.00%	Very Practical
Suitability (Alignment with Student Characteristics)	4.7	94.00%	Very Practical
Overall Average	**4.68**	**93.60%**	**Very Practical**

Practicality Results Based on Student Response

Student responses were critical in assessing the affective domain, focusing on the media's ability to generate Learning Interest as intended. The questionnaire directly assessed the elements of fun and engagement resulting from the integrated story and hands-on activities.

Table 4. Summary of product practicality based on student response

Practicality Aspect (Fun & Active)	Percentage of "Yes" Responses (%)	Practicality Criteria
Media is interesting and enjoyable	96.25%	Very Practical
Hands-on activities are easy to do and fun	93.75%	Very Practical
Science learning material is easier to understand	95.00%	Very Practical

The exceptionally high scores from the students, averaging 95.00%, strongly validate the product's primary goal: to make Science And Social Studies learning Fun and Active. The high score on the Hands-On activities is an easy-to-do and fun indicator (93.75%), confirming that the STEAM challenge, integrated within the story's context, was highly motivating and accessible for Grade III students. This practical success lays a strong foundation for the subsequent analysis of product effectiveness on Critical Thinking and Learning Interest.

Product Effectiveness Results

The final stage of the R&D process was measuring the product's effectiveness, which aimed to determine the extent to which the STEAM Hands-On Picture Story Book could significantly enhance students' Critical Thinking Skills and Learning Interest in Science And Social Studies. This test was conducted during the Implementation phase using a pre-test and post-test control group design. Students were randomly divided into an experimental group (receiving instruction with the developed media) and a control group (receiving conventional instruction). Effectiveness was determined by analyzing two primary instruments: a Critical Thinking multiple-choice test and a Learning Interest questionnaire. Data analysis utilized inferential statistics (T-Test) to confirm significant differences and the Normalized Gain (N-Gain) Score to measure the magnitude of improvement from pre-test to post-test.

Effectiveness on Critical Thinking Skills

The data analysis confirmed that the STEAM Hands-On Picture Story Book was effective in enhancing students' Critical Thinking Skills. The inferential analysis revealed a T-Test significance value (Sig. 2-tailed) of 0.000 ($p < 0.05$) between the post-test scores of the experimental and control groups, indicating a statistically significant difference attributable to the developed media. The average N-Gain Score for the experimental group was 0.65, placing the overall improvement in the High category. A deeper analysis, disaggregating the results by Facione's four simplified dimensions, provided insight into the specific skills most impacted by the STEAM model, as presented in Table 5.

Table 5. Summary of Critical Thinking Effectiveness Based on Facione's Dimensions

Critical Thinking Dimension (Facione)	Average Pre-test Score (%)	Average Post-test Score (%)	N-Gain Score	Improvement Criteria
Interpretation	55	90	0.78	High
Analysis	50	85	0.7	High
Inference	50	80	0.6	Medium
Evaluation	45	75	0.55	Medium
Overall Average	**50**	**82.5**	**0.65**	**High**

The effectiveness analysis confirmed that the intervention yielded the highest impact on strengthening the foundational Critical Thinking dimensions: Interpretation and Analysis. This significant gain is directly rooted in the integrated Engineering challenge embedded within the narrative structure of the storybook. Specifically, the students' ability to interpret (clarifying meaning) was profoundly amplified by the Picture Story Book. The rich visual and contextual data (e.g., the visual evidence and dialogue detailing the mutual benefit between Bubu the crocodile and Pipi the bird) served as the concrete, memorable case study needed by Grade III students. This narrative framework enabled students to accurately define and clarify the Symbiosis concepts using their own language, directly resulting in the highest N-Gain score in the Interpretation dimension.

While the higher-order dimensions of Inference and Evaluation also demonstrated improvement, they remained in the Medium category. This outcome is expected, given that Inference (drawing logical conclusions from limited data) and Evaluation (assessing the credibility or quality of an argument) represent the highest cognitive load within the simplified Facione framework. The results confirm that the product successfully prioritized scaffolding the necessary foundational skills (Interpretation and Analysis) essential for beginners in critical thinking, thus making significant progress within the developmental stage appropriate for Grade III students.

Effectiveness on Learning Interest

The effectiveness of the product in improving the affective domain, Learning Interest, was equally compelling. Analysis of the pre-test and post-test interest questionnaires showed a substantial overall increase in the experimental group, categorized as Very High. The improvement was analyzed based on Slameto's four indicators to pinpoint the most effective feature of the product, as summarized in Table 6.

Table 6. Summary of learning interest effectiveness based on Slameto's indicators

Critical Thinking Dimension (Facione)	Average Pre-test Score (%)	Average Post-test Score (%)	N-Gain Score	Improvement Criteria
Joy	70	95	25.00%	Very High
Attraction	65	90	25.00%	Very High
Acceptance	75	90	15.00%	High
Active Involvement	60	92	32.00%	Very High
Overall Average	**67.5**	**91.75**	**24.25%**	**Very High**

The data reveals that the indicator Active Involvement recorded the largest percentage increase (32.00%), making it the most impactful aspect of the media. This confirms the success of the STEAM Hands-On Model, demonstrating that integrating physical tasks and group challenges motivated students to move from passive learning (reading) to active investigation (Engineering), effectively transforming the learning process into a fun and engaging mission. The high scores in Joy and Attraction further solidify the media's success in cultivating a positive emotional environment for science learning.

DISCUSSION

The research findings unequivocally confirm that the developed STEAM Hands-On Picture Story Book satisfies the primary criteria for a successful educational product: validity, practicality, and effectiveness. The exceptionally high ratings achieved during the validation and practicality phases (all above 90%) established the product's foundational quality and

usability. This success is not merely procedural but reflects a necessary alignment between media design and the psychological needs of Grade III students, setting a robust stage for the subsequent analysis of the product's effectiveness in enhancing cognitive and affective outcomes.

The impressive practicality scores, particularly the 95.00% rating from students, underscore the effective power of the media. This result directly affirms the study's underlying hypothesis: that learning must be "fun and active" for elementary students. In theoretical terms, the media successfully lowered the affective filter by capitalizing on the appeal of visual storytelling (Art), which is essential for students operating within Bruner's iconic mode of representation (Alif, 2023; Fitriani et al., 2020). The high acceptance of the Joy and Attraction indicators of Slameto confirms the product's ability to generate immediate motivation necessary for sustained cognitive effort (Supriyadi, 2022).

Turning to the cognitive domain, the overall N-Gain score of 0.65 (High) on the Critical Thinking test demonstrates the product's significant superiority over conventional instruction. A detailed examination of the results by dimension shows that the highest gains were achieved in Interpretation (N-Gain 0.78) and Analysis (N-Gain 0.70). These foundational gains are critical because they represent the essential skills required for understanding the complexity of the science topic, Unique Relationships in Living Things (Symbiosis).

The significant strengthening of Interpretation is directly linked to the media's narrative success. The story of "Bubu and Pipi" provided a concrete, relatable case study that students could visually and emotionally grasp. This context enabled students to define and clarify the abstract concept of "mutualism" through the actions and dialogue of the characters. By providing rich visual data, the Picture Story Book effectively scaffolds the student's ability to decode meaning, which is the cornerstone of Critical Thinking according to Facione's framework (Kasanah et al., 2024; Nadhif & Utama, 2023).

The marked improvement in the Analysis dimension is a testament to the integrated Engineering Challenge. Analysis requires students to break down information into components and identify relationships a skill that the STEAM activity directly fostered. By requiring students to score the symbiotic relationship (+1, -1, 0) and use those scores to design a physical model that justifies their conclusion, the activity compelled them to analyze the "benefit or not" structure of the relationship before acting. This process transforms passive reception of facts into active structural analysis, effectively applying Higher-Order Thinking Skills (HOTS) in a hands-on environment (Putri & Mustadi, 2019).

Equally compelling is the product's impact on the affective variable, Learning Interest. The indicator Active Involvement recorded the largest percentage increase (32.00%). This finding confirms the success of the model's hands-on component. Active involvement, as the highest form of interest defined by Slameto, is achieved when the student physically and mentally participates in the learning process (Herpratiwi & Tohir, 2022). The integration of the Engineering task such as manipulating materials to create a representation of symbiosis transformed the student from a mere observer into an active researcher, driving participation and concentration throughout the lesson (Davidi et al., 2021).

The synergistic effect of the entire STEAM framework is evident here: the Story (Art) provided the motive and the visual data, and the Engineering Challenge (Action) provided the systematic application and physical task. This blend solved the key pedagogical problem of teaching abstract science to concrete thinkers (Aini et al., 2021; Widiana & Jampel, 2016). While the dimensions of Inference and Evaluation showed moderate gains, confirming the expected cognitive challenges for Grade III students, the solid improvement in Interpretation and

Analysis establishes a firm cognitive base upon which future, more complex critical thinking skills can be built (Amin et al., 2020).

A crucial factor supporting the media's effectiveness, particularly in scaffolding cognitive engagement, is the careful specification of the picture book's reading level as B3, optimally tailored for Grade III students. This strategic linguistic alignment ensures that the material does not impose an unnecessary cognitive load related to decoding complex vocabulary or ambiguous sentence structures (Arifah, 2020). Consequently, the high language validity scores confirmed that the product's vocabulary and syntax were appropriate, allowing students to focus their limited cognitive resources not on how to read, but on what to analyze. This characteristic directly bolstered the high practicality and learning interest results, as students felt less frustration and more enjoyment (Altun, 2019; Darmawati & Mustadi, 2023). By minimizing linguistic barriers, the B3 level maximized the students' capacity to engage with the STEAM Engineering challenge, enabling them to allocate cognitive effort toward practicing Interpretation and Analysis (Facione's dimensions) rather than struggling with basic comprehension.

CONCLUSION

The completion of this Research and Development process confirmed the high quality of the STEAM Hands-On Picture Story Book, as evidenced by achieving Very Valid (over 92%) and Very Practical (over 93%) criteria. Crucially, the media demonstrated significant effectiveness on both dependent variables, successfully validating the study's primary hypothesis. The most notable impact was the Very High increase in Learning Interest, primarily driven by the Active Involvement indicator (Slameto). This success confirms the model's ability to transform passive reading into engaging physical tasks by providing an emotional and narrative context. Concurrently, Critical Thinking skills improved with a High N-Gain (0.65). The highest gains were specifically observed in Interpretation and Analysis (Facione), the foundational critical thinking skills most appropriate for this age group. This targeted cognitive growth is directly attributable to the integrated Engineering challenge, which compelled students to analytically score and break down the symbiotic relationships before designing their physical model solution. In conclusion, the developed product effectively integrates the aesthetic appeal of the Story and Art with the methodological rigor of Hands-On Analysis, offering a concrete and motivating solution for enhancing both Critical Thinking and Learning Interest in Science and Social Studies subjects like Symbiosis.

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