

DEVELOPMENT OF A FLIPBOOK-BASED SCIENCE E-BOOK USING THE 5E LEARNING CYCLE TO ENHANCE FIFTH-GRADE STUDENTS' CRITICAL THINKING SKILLS

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ABSTRACT

This study aimed to develop a flipbook-based Science e-book for Theme 1, Light and Its Properties, integrated with the 5E Learning Cycle to support fifth-grade students' critical thinking skills. The study employed Research and Development (R&D) using the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. The participants were 30 fifth-grade students at SD Kristen Kalam Kudus 2 Pematangsiantar. Data were collected through expert validation, teacher and student response questionnaires, and critical thinking tests administered before and after implementation. The validation results showed very high validity, with scores of 88% from material experts, 86% from media experts, 92% from language experts, and 84% from test instrument experts. Practicality was also very high, based on student responses of 88% and teacher responses of 92%, with an average of 90%. The mean critical thinking score increased from 59.83 on the pretest to 86.17 on the posttest. The N-Gain score of 0.655 indicated a moderate improvement in critical thinking skills. The One-Sample t-Test yielded $p = 0.000 < 0.05$, indicating that the posttest mean was significantly higher than the KKTP of 75. Thus, the e-book was highly valid and practical and showed potential effectiveness in supporting students' critical thinking skills.

Keywords: e-book; Learning Cycle 5E; critical thinking skills

INTRODUCTION

The rapid development of technology and the demands of 21st-century education have changed the learning process, including in elementary schools. Education now emphasizes not only knowledge but also higher-order thinking skills, especially critical thinking. Sari (2024) explains that critical thinking involves analyzing and evaluating information to make appropriate decisions and conclusions. Rodiayan (2015) states that it includes asking relevant questions, identifying information, using logical reasoning, and drawing conclusions. Wulandari (2023) adds that critical thinking requires students to examine information carefully and systematically to determine appropriate actions. Previous studies have

shown that the Learning Cycle 5E can support critical thinking through the stages of engagement, exploration, explanation, elaboration, and evaluation. However, its implementation has mostly used conventional learning resources. Therefore, this study develops a flipbook-based Science e-book integrated with the 5E Learning Cycle for Theme 1, "Light and Its Properties," for fifth-grade students. This integration is expected to provide more active and meaningful learning experiences while supporting students' critical thinking skills.

Previous studies have examined digital learning materials and the Learning Cycle 5E, but these aspects have generally

been studied separately. Ningsih and Suciptaningsih (2024) developed a STEM-integrated IPAS e-module using a digital flipbook for elementary students and found high validity, practicality, and improvement in critical thinking skills. Similarly, Nuryanti et al. (2025) developed a scientific-approach-based e-book to support students' critical thinking and reported very high feasibility. These findings show the potential of e-books and flipbooks to support critical thinking. However, based on these studies, the integration of a flipbook-based e-book with all five stages of the 5E Learning Cycle for the topic "Light and Its Properties" in fifth-grade elementary education remains underexplored.

One subject with significant potential for developing critical thinking skills is Natural and Social Sciences (IPAS). In the Independent Curriculum, IPAS is a subject that integrates the study of natural and social sciences. The Ministry of Education and Culture (2022) asserted that IPAS encompasses the study of living organisms, non-living objects, the universe, and the relationships among them including human beings in individual and social contexts. In addition to introducing students to an assorted array of natural and social manifestations, IPAS learning plays an important role in fostering critical thinking abilities (Meryna et al., 2023). Consequently, the implementation of IPAS should involve meaningful learning activities that encourage students to observe phenomena, investigate problems, relate scientific concepts to their surrounding environment, and formulate conclusions according to the information and experiences they obtain. Kisworo et al. (2023) emphasize that the integration of natural and social sciences in IPAS is

expected to produce meaningful learning through the development of attitudes, concepts, processes, and their application in life.

To achieve these goals, teaching materials are needed that can support systematic and engaging learning. Suprihatin and Supranoto (2018) explain that teaching materials are intermediary media containing learning materials that are systematically and engagingly designed. One form of teaching material that is in line with technological developments is the e-book. Martha et al. (2018) explain that e-books are a digitalization of conventional books. As a digital learning medium, e-books can contain varied multimedia aspects, like images, text, video, animation, audio, graphics, hyperlinks, and quizzes, thus providing a more interactive learning experience (Komalasari & Susantini, 2024). With these characteristics, e-books can be used as an alternative teaching material that supports independent learning, is engaging, and in line with developments in educational technology.

However, learning conditions in schools indicate that the use of science teaching materials still faces various limitations. Based on observations, interviews, and documentation in Grade V at SD Kristen Kalam Kudus 2 Pematangsiantar, learning activities predominantly rely on textbooks as the main learning resources. Teachers have not yet developed systematic and innovative digital teaching materials that are aligned with students' learning needs. The use of technology in learning is also limited, including PowerPoint presentations that are largely text-based. These conditions result in less varied learning experiences and provide limited opportunities for students to actively explore concepts, exchange ideas,

solve problems, and develop critical thinking skills. Furthermore, observations and interviews indicated that the availability of textbooks was still limited, while supplementary instructional materials were insufficient. Consequently, students had limited learning resources that could encourage active participation and deeper engagement in science learning activities. Similar conditions have been identified in previous research. Purnama et al. (2025) reported that elementary school teachers continued to rely predominantly on conventional learning resources, while the use of digital media remained limited. The study also indicated a need for interactive digital media that are aligned with learning content and capable of stimulating students' critical thinking.

These conditions indicate the need for learning resources that not only present scientific concepts but also provide structured activities to develop critical thinking. The Learning Cycle 5E provides a framework through five interconnected phases. In the Engagement phase, students activate prior knowledge, identify problems, and formulate relevant questions, supporting basic clarification. The Exploration phase allows students to investigate phenomena, collect information, and identify relationships among concepts, supporting evidence-based reasoning. In the Explanation phase, students communicate findings and provide logical explanations, strengthening inference and argumentation. The Elaboration phase encourages students to apply concepts to new situations, analyze problems, and develop appropriate solutions, supporting strategic decision-making. Finally, the Evaluation phase enables students to assess their understanding, evaluate their reasoning,

and draw evidence-based conclusions. Thus, integrating the 5E Learning Cycle into digital science teaching materials can provide structured learning experiences that support the development of students' critical thinking skills.

This need is also reflected in students' learning outcomes. Documentation of Grade VA learning scores in the 2025/2026 academic year showed that 17 of 30 students (56.67%) had not achieved the Learning Objective Achievement Criteria (KKTP) of 75. Teacher interviews also indicated that students' critical thinking skills were still relatively low, particularly at the analysis (C4) and evaluation (C5) levels. Although students could recall the material presented by the teacher, they still experienced difficulties in providing reasons, analyzing information, solving problems, and drawing conclusions. Therefore, learning activities need to place greater emphasis on thinking processes and active student engagement.

One alternative to address these issues is to develop an e-book in the form of a flipbook combined with the 5E Learning Cycle model. The technology and electronic media use can aid to raise the appeal of learning and facilitate student understanding (Putri & Sobari, 2020). In this study, the e-book was written in flipbook form, allowing for digital presentation of material through a combination of text, images, videos, illustrations, learning activities, and practice questions. These characteristics allow for a more engaging presentation of learning materials while also providing opportunities for students to learn independently and interactively.

Recent research has further demonstrated the importance of digital learning media that explicitly facilitate

critical thinking in elementary science education. Purnama et al. (2025) found that teachers in elementary schools still relied heavily on conventional learning resources, while interactive digital media were considered necessary to stimulate students' critical thinking skills. This finding reinforces the need to develop digital learning materials that are not only attractive but also specifically designed to facilitate higher-order thinking processes.

The e-book was designed by incorporating the 5E Learning Cycle, which is based on constructivist learning theory. Bybee (2018) explains that the 5E Learning Cycle helps students reorganize ideas, strengthen thinking skills, and develop deeper conceptual understanding through systematic learning phases. Similarly, Cardak et al., as cited in Sadia (2014), state that the model reflects constructivist principles by encouraging students to construct knowledge through direct experiences and active participation. The model consists of five sequential stages: engagement, exploration, explanation, elaboration, and evaluation (Imran et al., 2020). In addition, Munjiah et al. (2025) reported that flipbook-based teaching materials can attract students' attention through visual and animated content, support conceptual understanding, and facilitate activities such as project-based learning, group discussion, and independent evaluation.

The five stages of the 5E Learning Cycle support the development of students' critical thinking skills. In the engagement stage, students activate prior knowledge and relate it to problems or phenomena presented in learning. The exploration stage provides opportunities to investigate and gain direct experience. The explanation stage encourages students to communicate

observations and develop conceptual understanding, while elaboration allows them to apply concepts to different situations. Finally, the evaluation stage assesses students' understanding and learning abilities. Through these stages, students become active participants and have opportunities to develop deeper thinking skills.

The contribution of the 5E Learning Cycle to critical thinking is supported by previous studies. Mayangsari et al. (2015) found that the model can strengthen critical thinking, particularly in analyzing, interpreting, explaining, and evaluating information. Eroglu and Bektas (2022) described the 5E Learning Cycle as a student-centered approach in which teachers act as facilitators and students actively explore concepts, participate in discussions, and develop deeper understanding. Similarly, Tanfiziyah et al. (2021) found that the model supports students' cognitive potential through active participation and meaningful learning interactions. Recent evidence from Eduproxima also supports its use in science learning. Frasiska et al. (2025) found that the 5E Learning Cycle assisted by Quizwhizzer significantly influenced students' cognitive learning outcomes, with an N-Gain of 0.53 in the experimental group compared with 0.16 in the control group. These findings indicate that the 5E Learning Cycle can provide a structured learning environment that supports students' learning development.

The combination of a flipbook-based e-book and the 5E Learning Cycle is expected to produce teaching materials that are visually appealing while guiding students through active, exploratory, and constructive learning. E-books provide digital materials that can integrate various

multimedia elements, while the 5E Learning Cycle structures learning through experience, exploration, explanation, application, and evaluation. In the topic of “Light and Its Properties,” this combination allows students to observe light phenomena, conduct simple explorations, explain their observations, apply concepts to everyday life, and evaluate their understanding. Therefore, integrating e-books with the 5E Learning Cycle can support active, exploratory, and meaningful science learning while fostering students’ critical thinking skills.

Based on the discussion above, the development of digital teaching materials that combine e-books with an appropriate learning model is needed to support students’ cognitive development. Therefore, this study focuses on developing a flipbook-based e-book for Science (IPAS) Theme 1, “Light and Its Properties,” for fifth-grade elementary school students. The study aims to evaluate the validity, practicality, and effectiveness of the developed product in supporting students’ critical thinking skills. The resulting e-book is expected to serve as an innovative and interactive digital learning resource that meets students’ learning needs and supports science learning in elementary schools.

METHOD

This study used a Research and Development (R&D) method to develop a flipbook-based Science e-book on Theme 1, “Light and Its Properties,” integrated with the 5E Learning Cycle. R&D is used to develop and assess educational products through systematic procedures (Sugiyono, 2019). The development followed the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009).

The study was conducted at SD Kristen Kalam Kudus 2 Pematangsiantar from April to June 2026. The participants included fifth-grade students, science teachers, and experts in material, media/design, language, and test instruments. Data were collected through observations, interviews, documentation, expert validation, teacher and student questionnaires, and critical thinking tests. The study focused on developing a flipbook-based Science e-book integrated with the 5E Learning Cycle to support students’ critical thinking skills.

The product was evaluated using a one-group pretest-posttest design. Students completed a pretest before using the e-book and a posttest after the implementation. The results were compared to identify changes in students’ critical thinking skills. This design has also been used in recent educational studies to examine changes in students’ critical thinking and science-related abilities after learning interventions (Rahayu & Suwito, 2025; Isrianti & Ismiyanti, 2025; Nurfadiah & Hidayatullah, 2026). Since the study used only one group without a control group, the results were interpreted as evidence of improvement rather than strong evidence of causal effectiveness. This limitation is important because changes observed between the pretest and posttest may also be influenced by factors other than the developed e-book.

The development followed the five stages of the ADDIE model (Branch, 2009; Sugiyono, 2022). Analysis Stage. The analysis stage identified students’ learning needs, curriculum requirements, and existing learning conditions. Classroom observations and teacher interviews were conducted to identify problems in science learning and determine the requirements for

developing the e-book. The analysis also considered students' characteristics and the learning objectives for Theme 1, "Light and Its Properties."

Design Stage. The design stage involved preparing the e-book structure, selecting and organizing the content, designing learning activities, and planning the visual presentation. The content was aligned with the Learning Achievements and Learning Objectives for Grade V Science. The e-book activities were organized according to the five stages of the 5E Learning Cycle: engagement, exploration, explanation, elaboration, and evaluation. The design also considered readability, visual appeal, and ease of use (Prastowo, 2015).

Development Stage. The design was developed into a flipbook-based e-book containing learning materials, illustrations, videos, learning activities, critical-thinking questions, and evaluations. The initial product was reviewed by material, media/design, language, and test instrument experts. Their assessments were used to revise the product before implementation. A limited trial was conducted with five fifth-grade students selected purposively based on recent learning achievement data provided by the classroom teacher. The students represented high, medium, and low academic ability. The selection was intended to obtain diverse information about the usability of the e-book rather than to compare academic achievement. Students used the e-book with researcher guidance and then completed a response questionnaire covering material clarity, language readability, visual presentation, ease of use, and the suitability of activities with the 5E Learning Cycle. The results were used to identify aspects requiring revision.

Implementation Stage. The revised e-book was implemented in one fifth-grade class on the topic "Light and Its Properties." Students participated in learning activities based on the five stages of the 5E Learning Cycle. The practicality of the product was assessed through teacher and student responses, while changes in critical thinking skills were examined through pretest and posttest results.

Evaluation Stage. The evaluation stage involved reviewing the product based on expert validation, teacher and student responses, and students' critical thinking test results. The findings were used to determine the validity, practicality, and improvement in learning outcomes and to finalize the e-book. The critical thinking test was developed from established critical thinking indicators. Facione (2015) identifies important critical thinking skills, including interpretation, analysis, evaluation, inference, explanation, and self-regulation. These indicators were adapted to the topic of "Light and Its Properties" and translated into a test blueprint. The blueprint guided the development of items requiring students to analyze phenomena, provide evidence-based reasons, draw conclusions, and determine appropriate solutions.

Before use, the test was reviewed by experts to assess the relevance, clarity, and alignment of the items with the intended indicators. The instrument was also tested to determine item validity, reliability, discrimination, and difficulty level. The scoring criteria were aligned with the critical thinking indicators. Students' item scores were summed and converted into achievement scores, with higher scores indicating stronger critical thinking performance.

The research instruments consisted of expert validation sheets, teacher and student response questionnaires, and critical thinking tests. Expert validation assessed the product in terms of material, media/design, language, and test instruments. Teacher and student questionnaires were used to determine the practicality of the e-book. Critical thinking tests were administered as pretests and posttests to measure students' performance before and after implementation.

Expert validation data were analyzed descriptively using percentage scores. The validity criteria were as follows: 85.01%–100% = very valid, 70.01%–85% = valid, 50.01%–70% = less valid, and 1%–50% = invalid. Practicality data were obtained from teacher and student questionnaires using a five-point Likert scale. The interpretation followed Akbar (2013) and Arikunto (2014), with 80%–100% categorized as very practical.

The improvement in students' critical thinking skills was analyzed using N-Gain. Hake (1998) explains that normalized gain can be used to examine the improvement between pretest and posttest performance. In this study, N-Gain was interpreted as high (≥ 0.70), moderate ($0.30 < 0.70$), and low (< 0.30).

A normality test was conducted as a prerequisite for parametric analysis. A One-Sample t-Test at a significance level of 5% was then used to determine whether the mean posttest score was significantly higher than the KKTP of 75. If Sig. (2-tailed) < 0.05 , the mean posttest score was considered significantly different from the reference value. The analysis resulted in $t = 5.837$, $df = 29$, and Sig. (2-tailed) = 0.000, with a mean posttest score of 86.167. Therefore, the students' mean posttest score

was significantly higher than the KKTP of 75.

RESULTS AND DISCUSSION

This research developed a flipbook-based Science e-book for Theme 1, "Light and Its Properties," using the 5E Learning Cycle to improve fifth-grade students' critical thinking skills. The product was developed using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The research involved 30 fifth-grade students at SD Kristen Kalam Kudus 2 Pematangsiantar. The developed e-book was evaluated based on its validity, practicality, and effectiveness.

1. Validity of the 5E Learning Cycle-Based Science E-Book

Product validity was assessed by material experts, media/design experts, language experts, and test instrument experts. The assessment was conducted using a validation sheet with a Likert scale. Based on the criteria used in the study, a percentage of 85.01%–100% is considered highly valid. The summary of product validation results is presented in Table 1.

Table 1. Validation Results of the 5E Learning Cycle-Based Science E-Book

Validator	Maximum Score	Acquisition Score	%	Category
Subject matter expert	75	66	88%	Very worthy
Design expert	50	43	86%	Very worthy
Linguist	50	46	92%	Very worthy
Test instrument expert	50	43.5	87%	Very worthy

Source: Research data.

The validation results showed that the developed e-book met the criteria for use in learning, with scores of 88% from the material expert, 86% from the media/design

expert, 92% from the language expert, and 87% from the test instrument expert. These results indicate high validity in terms of content, design, language, and assessment. The material was evaluated based on its alignment with learning outcomes, conceptual accuracy, presentation, and integration of the 5E Learning Cycle. Based on expert suggestions, revisions included improving the alignment of learning objectives, images, illustrations, font size, page layout, and critical thinking assessments, as well as clarifying activities according to the five 5E phases. The language validation score of 92% indicates that the e-book uses clear, communicative, and age-appropriate language. Consistency received the highest score (100%), followed by language suitability (92%) and readability (86.67%). These results indicate that the language facilitates students' understanding and supports independent learning.

The material content was developed according to the characteristics of fifth-grade students and the learning objectives for the topic "Light and Its Properties." The concepts were presented not only through explanations but also through observation activities and problem-solving tasks. The integration of the 5E Learning Cycle provided opportunities for students to activate prior knowledge, explore phenomena, explain concepts, apply knowledge, and evaluate their understanding. Thus, the e-book provides a structured learning experience that can support students' active participation and critical thinking.

The findings are consistent with previous studies showing that digital teaching materials, including e-books and flipbooks, can support science learning by presenting interactive and accessible learning content. In this study, the N-Gain score of 0.655 indicated a moderate improvement in students' critical thinking

skills after using the e-book. This finding suggests that the product supported students' critical thinking development, although the improvement did not reach the high category. Furthermore, because the study used a one-group pretest-posttest design without a control group, the improvement cannot be attributed solely to the developed e-book. Other factors, such as classroom interaction, prior learning experiences, and repeated exposure to the material, may have contributed to the observed improvement. Nevertheless, the combination of high validation results, practical responses, and improved posttest performance indicates that the flipbook-based e-book integrated with the 5E Learning Cycle has potential as a digital learning resource for supporting fifth-grade students' critical thinking skills.

The language aspect's validity of 92% also demonstrates that language is one of the product's strengths. Simple, communicative, and developmentally appropriate language helps students grasp the concepts presented. Consistency in terms, symbols, and icons also enhances the e-book's readability, making it easier for students to follow the learning activities. Thus, validation from various experts indicates that the developed e-book meets the content and presentation requirements for use as a science and science teaching material. Revisions based on validator input were also crucial in producing a final product that better meets learning needs.

2. Practicality of the IPAS E-Book

The product's practicality was determined through student and teacher responses after using the e-book in learning. Practicality was assessed using a Likert-type questionnaire. Based on research criteria, a percentage of 80%–100% is considered very practical.

Table 2. Practical Results of the IPAS E-Book

Respondents	%	Category
Student	88%	Very practical
Teacher	92%	Very practical
Average	90%	Very practical

Source: Research data.

The results showed that student response to the e-book reached 88%, while teacher response reached 92%, with an average practicality rating of 90%. Thus, the 5E Learning Cycle-based science e-book falls into the very practical category. In a limited trial involving five students, student responses also showed positive results. The average response rate reached 90%, with the display aspect scoring 90%, ease of use 88%, material clarity 92%, language use 89%, and relevance to critical thinking skills 91%.

The results showed that the e-book achieved an average practicality rating of 90%, consisting of 88% student responses and 92% teacher responses. These results indicate that the product is not only theoretically valid but also easy to use in learning practice. The high level of practicality can be attributed to the characteristics of e-books, which combine text, images, illustrations, learning activities, and evaluations in a single digital learning resource. The flipbook format provides a reading experience more similar to a book while still utilizing the advantages of digital media. For students, these characteristics can increase their interest and facilitate independent learning.

Practicality is also reinforced by the 5E Learning Cycle structure contained in the e-book. The engagement stage helps draw students' attention to light phenomena; the exploration stage provides opportunities for students to make observations; the explanation stage helps students explain their findings; the

elaboration stage encourages the application of concepts in other situations; and the evaluation stage is used to measure student understanding.

These results support previous research showing that practicality is a crucial aspect in determining whether a teaching material can be applied effectively in learning. Products with a clear learning structure, attractive presentation, and ease of use tend to receive positive responses from both teachers and students. Thus, the 5E Learning Cycle-based Science e-book can be said to be practical because it can be used by students and teachers without requiring excessive additional explanation and is able to support the implementation of learning activities.

3. The Effectiveness of E-Books in Improving Critical Thinking Skills

The effectiveness of the developed e-book was assessed by examining the differences in students' critical thinking abilities before and after the learning intervention. Prior to its use, the assessment instrument underwent analysis to determine its validity, reliability, item discrimination, and difficulty level, ensuring that the instrument was appropriate for measuring students' critical thinking skills. Of the 30 test items, 20 were valid and 10 were invalid. The valid items were then used as research instruments.

Table 3. Recapitulation of Test Instrument Validity

Criteria	Number of Questions	Question Number
Valid	20	1, 2, 3, 4, 5, 7, 8, 10, 12, 14, 16, 17, 18, 19, 21, 23, 25, 26, 28, 29
Invalid	10	6, 9, 11, 13, 15, 20, 22, 24, 27, 30

Source: Research data.

The reliability test results showed an r_{11} coefficient of 0.889, indicating that the instrument has very high reliability. Therefore, the instrument can be trusted to measure students' critical thinking skills. Furthermore, the results of the students' pretest and posttest are presented in Tab. 4.

Table 4. Results of Pretest and Posttest of Critical Thinking Skills

Statistics	Pretest	Posttest
Number of students	30	30
The highest score	85	100
	Pretest	Posttest
Number of students	30	30
The highest score	85	100
Lowest value	35	65
Total value	1,795	2,845
Average	59.83	86.17

Source: Research data.

Table 4 presents the students' critical thinking performance before and after the implementation of the e-book. The findings indicate a notable improvement, as the mean score rose from 59.83 in the pretest to 86.17 in the posttest, representing an increase of 26.34 points. In addition, the maximum score improved from 85 to 100, while the minimum score increased from 35 to 65. Prior to conducting the hypothesis test, the pretest and posttest scores were examined for normality using the Shapiro-Wilk test. This test was selected because the number of participants was below 50.

The Shapiro-Wilk test produced a significance value of 0.647 for the pretest data and 0.058 for the posttest data. Since both values exceeded the 0.05 significance level, the two datasets can be considered normally distributed. Therefore, the normality assumption was satisfied, allowing the data to be further analyzed using parametric statistical procedures.

Following the normality test, an N-Gain analysis was performed to measure the extent of improvement in students' critical thinking skills after the implementation of the developed e-book.

Table 5. N-Gain Test Results

Component	Mark
Pretest average	59.83
Posttest average	86.17
Maximum score	100
N-Gain	0.655
Category	Currently

Source: Research data.

The N-Gain analysis resulted in a score of 0.655, which is classified as moderate because it falls within the range of $0.30 \leq g \leq 0.70$. This finding demonstrates that the implementation of the 5E Learning Cycle-based e-book contributed to a moderate improvement in students' critical thinking abilities. To further examine the effectiveness of the developed product, an additional statistical test was conducted to determine whether the mean posttest score had significantly surpassed the established KKTP of 75.

Table 6. One-Sample t-Test Results

Component	Mark
Test Value	75
t count	5,837
df	29
Sig. (2-tailed)	0,000
Mean Difference	11,167
Lower CI 95%	7.25
Upper CI 95%	15.08

Source: Research data.

The One-Sample t-Test produced a t-value of 5.837 with 29 degrees of freedom (df) and a 0.000 p-value. Because the p-value is below 0.05, the null hypothesis (H_0) is rejected, while the alternative hypothesis (H_a) is accepted. The posttest mean of 86.17 is significantly higher than the reference value of 75. The 95% confidence interval of 7.25–15.08 also

indicates that the mean difference is above zero.

The study output demonstrates that the implementation of the 5E Learning Cycle-based e-book contributed to the improvement of students' skills of critical thinking. This improvement can be observed from the increase in the students' mean achievement, which rose from 59.83 in the pretest to 86.17 in the posttest. The difference of 26.34 points reflects a positive change in students' critical thinking performance following the learning activities supported by the developed e-book.

In the initial conditions, the average student ability was still below the KKTP 75. This condition shows that before being given learning using e-books, students were not optimal in analyzing problems, connecting the concept of light with everyday life phenomena, and drawing conclusions based on the information obtained.

After using the 5E Learning Cycle-based e-book, the average posttest score increased to 86.17. This improvement can be explained by the 5E Learning Cycle's characteristics, which position students as active participants in learning. Students not only receive teacher explanations but also have the opportunity to observe phenomena, explore information, explain observations, apply concepts, and evaluate their understanding.

The engagement stage serves to build attention and activate students' prior knowledge. In the exploration stage, students are guided to obtain information through observation or investigation. The explanation stage then provides students with the opportunity to construct and communicate their understanding. Next, the elaboration stage encourages students to

apply concepts to different situations, while the evaluation stage helps students assess their level of conceptual mastery and thinking skills.

This process is closely related to critical thinking skills because students are required to analyze information, provide explanations, use evidence, connect concepts, and draw conclusions. Therefore, improved grades after using e-books not only demonstrate improved mastery of the material but also indicate the development of students' thinking processes.

The N-Gain score of 0.655 indicated a moderate improvement in students' critical thinking skills after using the developed e-book. This improvement may be related to the structured learning activities in the five phases of the 5E Learning Cycle. In the Engagement phase, students activated prior knowledge by responding to questions and phenomena related to light. During Exploration, they investigated light phenomena, collected information, and analyzed relationships among concepts. In the Explanation phase, students communicated their findings and developed logical explanations, while Elaboration encouraged them to apply concepts to new situations and solve contextual problems. Finally, the Evaluation phase provided opportunities to assess their understanding, reasoning, and conclusions based on the evidence obtained. These activities may have supported the development of students' critical thinking skills. However, because the N-Gain was in the moderate category and the study used a one-group pretest-posttest design without a control group, the findings should be interpreted as evidence of improvement rather than strong causal effectiveness. Future development could strengthen investigative activities and

include more higher-order thinking questions to further support students' critical thinking skills.

The findings of this study are in line with earlier studies reporting that the application of the 5E Learning Cycle produces a significant improvement in students' critical thinking abilities when compared with conventional instructional approaches. Furthermore, previous studies have indicated that learning materials developed using the 5E Learning Cycle generally demonstrate good levels of validity and practicality and are effective in facilitating the development of students' critical thinking skills.

Furthermore, previous studies on flipbook-based e-modules have demonstrated that combining various learning components, including written content, visual materials, videos, and practice activities, can facilitate the development of students' critical thinking abilities. Such integration provides students with opportunities to engage actively with learning materials and construct their understanding through meaningful learning experiences.

Statistically, the product's effectiveness is further strengthened by the results of the One-Sample t-Test. A sig. value of $0.000 < 0.05$ indicates that the posttest average differs significantly from the benchmark score of 75. The posttest average of 86.17 is 11.17 points above the KKTP. Thus, the use of the 5E Learning Cycle-based e-book produces learning outcomes that significantly exceed the established completion standards.

These results demonstrate that the effectiveness of e-books is not only demonstrated by descriptive score improvements but also supported by statistical analysis. Based on these findings,

the developed e-book has the potential to serve as an alternative digital instructional resource for IPAS learning, particularly in supporting the development of critical thinking skills among fifth-grade elementary school students.

4. Key Research Findings

Based on the overall results, this study shows that the development of an IPAS e-book in the form of a flipbook based on the 5E Learning Cycle fulfills three main aspects of product quality, namely valid, practical, and effective.

Table 7. Summary of Research Results

Aspect	Results	Category
Subject matter expert validation	88%	Very worthy
Media/design expert validation	86%	Very worthy
Linguist validation	92%	Very worthy
Validation of test instruments	87%	Very worthy
Student practicality	88%	Very practical
Teacher practicality	92%	Very practical
Average practicality	90%	Very practical
Pretest average	59.83	—
Posttest average	86.17	—
N-Gain	0.655	Currently
One-Sample t-Test	t = 5.837; Sig. = 0.000	Significant

Source: Research data.

Overall, the findings demonstrate that the Science e-book developed through the 5E Learning Cycle possesses a high level of product quality. The validation results confirm that the e-book fulfills the required standards related to content, visual design, language, and assessment. The practicality findings further indicate that the product

can be used conveniently by both teachers and students during the learning process. In terms of effectiveness, the improvement in students' scores from the pretest to the posttest, supported by an N-Gain score of 0.655 and the results of statistical analysis, confirms that the e-book contributes positively to the development of students' critical thinking skills.

Based on these findings, the flipbook-based Science e-book for Theme 1, "Light and Its Properties," which incorporates the 5E Learning Cycle, can be utilized as an alternative digital learning resource in elementary science education. The product provides opportunities for students to engage more actively and interactively in the learning process while encouraging them to analyze information and develop critical thinking. Therefore, the final product can be categorized as very valid, very practical, and effective in backing the enhancement of skills of critical thinking among fifth-graders.

CONCLUSION

The findings of the research and development process indicate that the Science E-Book for Theme 1, "Light and Its Properties," developed by integrating the 5E Learning Cycle provides a feasible digital learning resource for fifth-grade elementary science instruction. The product achieved very high validity, with scores of 88% from material experts, 86% from media experts, 84% from test instrument experts, and 92% from language experts. Its practicality was also categorized as very high, based on student and teacher responses of 88% and 92%, respectively, with an overall average of 90%.

In terms of learning outcomes, students' mean critical thinking scores increased from 59.83 on the pretest to 86.17

on the posttest. The N-Gain score of 0.655 indicates a moderate level of improvement, meaning that the e-book was associated with a meaningful improvement in students' critical thinking performance, although the increase did not reach the high category. The One-Sample t-Test produced a significance value of 0.000 (2-tailed), which was lower than 0.05, indicating that the posttest mean was significantly higher than the reference value of 75. However, because the study employed a one-group pretest-posttest design, these findings should not be interpreted as strong causal evidence of effectiveness.

The main contribution of this study lies in integrating the interactive features of a flipbook-based digital resource with the structured learning processes of the 5E Learning Cycle. This integration provides opportunities for students to engage with phenomena, investigate information, explain their reasoning, apply concepts to new situations, and evaluate their understanding. Thus, the developed e-book offers a practical digital learning resource that can facilitate active learning and support the development of critical thinking skills in elementary science education.

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