Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar JPPGuseda

Volume 8 Issue 3 Year 2025 Pages 145-153
ISSN 2623-0941 | e–ISSN 2623-0232
https://jppguseda-fkip.unpak.ac.id
DOI: 10.55215/jppguseda.v8i3.18

Development of STEAM-Based Flipped Books to Cultivate a Growth Mindset in Elementary School Students

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Abstract: This study aims to develop a STEAM-based flipbook to foster a growth mindset among elementary school students. This study was conducted at government elementary school with a sample of 25 students. This research is used the 4D development model consisting of Define, Design, Develop, and Disseminate. Data collection involved expert validation, practicality testing, and effectiveness assessment. The results showed that the developed STEAM-based flipbook met the validity criteria with a score of 87%, categorized as very valid. The practicality level also exceeded 80%, indicating that the product is easy to use, engaging, and supports independent and collaborative learning activities. The effectiveness test showed a significant improvement in student outcomes, with a pre-test average of 75% increasing to 89% in the post-test, reflecting strengthened growth mindset indicators such as persistence, willingness to explore new strategies, and positive responses to challenges. Overall, the STEAM-based flipbook developed through the 4D model proved valid, practical, and effective in fostering a growth mindset among elementary school students.

Keywords: elementary schools; flipped-book; growth mindset; stem

Article info: Submitted November 5, 2025 | Revised November 18, 2025 | Accepted November 27, 2025

Recommended citation: Pratiwi, S. D., Kasmini, L., Syarfuni, & Sari, S. M. (2025). Development of STEAM-based flipped books to cultivate a growth mindset in elementary school students. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, *8*(3), 145–153. https://doi.org/10.55215/jppguseda.v8i3.18

Introduction

Education is a systematic process aimed at developing individual potential, intellectually, emotionally, socially, and morally. More than just transferring knowledge from one generation to the next, education also shapes character, skills, and values that are useful in personal and social life (Maulida et al., 2023; Jackson, 2019). Education can be obtained through various channels, both formal, non-formal, and informal (Andayani et al., 2025). Formal education includes levels from elementary school to higher education, while non-formal education covers courses and training outside the school system, and informal education takes place in family and community environments (Nimodiya & Ajankar, 2022; Boykov & Goceva, 2019). The purpose of education is to optimally develop individual potential so that they can contribute to personal, social, and professional life. In general, education aims to create knowledgeable, moral, and skilled individuals needed in society (Razali et al., 2024). Education plays an important role in shaping quality human resources, especially in the era of the Industrial Revolution 4.0, which demands individuals to have critical, creative, and innovative thinking skills (Celik et al., 2022). 21st-century skills include critical thinking, creativity, collaboration, and communication (4C). One of the subjects that plays a role in developing these skills is science (Fatmi & Fauzan, 2022). However, the reality in the field shows that Science learning in elementary schools still faces various obstacles, such as low student interest in learning, less interactive teaching methods, and limited innovative learning media (Pakpahan et al., 2020). These problems are in line with the researcher's findings, which indicate that conventional teaching methods are still dominant, making students tend to be passive and less motivated in understanding often abstract Science concepts. In addition, the lack of interactive learning media is also a contributing factor to students' low critical thinking skills in science (Arni et al., 2024; Sari et al., 2022). To overcome these challenges,

innovation in teaching materials is very necessary to improve the effectiveness of Science learning (Syahirah et al., 2020).

One promising innovation in the development of teaching materials is the use of Flipped-Book media. A flipped-book is an interactive digital teaching material that presents material in the form of text, images, audio, and video, making it more attractive and easy for students to understand. Flipped-books allow the integration of text, images, animations, and videos, which can enhance conceptual understanding and learning appeal for students (Safaruddin et al., 2020). Flipped-Books in learning can increase students' learning motivation and facilitate a deeper understanding of concepts (Hasanah et al., 2023). Another advantage of flipped-book Science teaching materials is their flexibility in being accessed by students anytime and anywhere through digital devices such as computers, tablets, or smartphones (Kasmini et al., 2024). This strongly supports independent learning, where students can review material according to their needs without having to rely on printed books (Keskin & Yurdugül, 2020). Technology in Science learning can increase student motivation and enable them to learn more actively and independently. In addition, teachers also find it easier to adjust and update material according to curriculum developments and learning needs (Anggraini & Hudaidah, 2021). With interactive features such as quizzes and practice questions, flipped-books can increase student engagement in learning, so they are more active in understanding and testing their comprehension of the material being learned (Hunaepi et al., 2020). Flipped-Book Science teaching materials are digital learning media based on interactive books specifically designed to present Science material in a more engaging and easily understandable way for students (Celik et al., 2022). Flipped-books allow students to interact with the material through a combination of text, images, videos, animations, and other interactive elements that help students understand Science concepts more concretely and deeply. Effective learning media must be able to attract students' attention, increase learning motivation, and facilitate material comprehension. Flipped-books meet all three criteria by providing a more dynamic and interactive learning experience. The material presented in Science flipped-books is usually made more visual with illustrations, diagrams, and interactive simulations to help students understand abstract concepts more easily.

One approach that can improve the quality of science learning is the application of the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach. STEAM is a learning approach that integrates concepts from science, technology, engineering, arts, and mathematics to equip students with problem-solving, critical thinking, and innovation skills. The STEAM approach is a multidisciplinary approach to education that connects concepts from science, technology, engineering, arts, and mathematics to produce innovative and real-world problem-solving. This approach aims to enhance growth mindset, creativity, collaboration, and problem-solving, which are important in the continuously evolving modern world (Pradana, 2025; Pramudyani et al., 2025; Fauziyah & Palennari, 2024; Prameswari & Lestariningrum, 2020). STEAM education is designed to prepare students to face global challenges by building a deeper understanding of scientific and technological concepts and their application in daily life. Science serves as the main foundation in STEAM, covering disciplines such as physics, chemistry, biology, and environmental science. Through science, individuals can understand the basic principles of nature and how scientific phenomena occur. STEAM-based learning can help students develop skills such as analytical thinking, creativity, communication, and collaboration (Jayanti & Yunianta, 2022; Nurramadhani et al., 2021). Characteristics of STEAM learning, namely interdisciplinary (integrating various disciplines), problem-solving oriented (presenting real challenges that require scientifically based problem-solving), technology utilization (involving the use of tools and technology), and creativity enhancement (encouraging students to find innovative solutions) (Fatma, 2021). The application of STEAM learning in science can enhance students' understanding of scientific concepts and develop critical and creative thinking skills. Therefore, this approach is very relevant to be applied in the development of Science Flipped-Book teaching materials.

However, the implementation of STEAM in science learning at the elementary school level still faces various challenges. Based on research conducted by Capraro et al. (2013), many teachers still find it difficult to implement STEAM-based learning due to the lack of teaching materials suitable for the characteristics of elementary school students. In addition, the use of conventional text-based learning media is considered less engaging for students and unable to optimally support STEAM-based learning. Therefore, it is necessary to develop teaching materials that can accommodate the STEAM approach and increase student engagement in the learning process. 21st-century learning demands that students not only master academic knowledge but also possess critical, creative, collaborative, and communicative thinking skills. One relevant approach to developing these skills is STEAM-based learning. The STEAM approach encourages students to explore various disciplines in an integrated manner through challenging and contextual activities, which can improve problem-solving and innovative thinking skills. In the process, students are required to think openly, try various solutions, and not be afraid to fail. This is in line with the concept of a growth mindset, which is the belief that an individual's abilities can be developed through effort, appropriate strategies, and learning from mistakes. A

growth mindset is the belief that one's basic abilities can be developed through dedication and hard work. This concept was first developed by Carol S. Dweck, a professor of psychology at Stanford University. GM "growth mindset is the belief that intelligence and abilities can be developed with effort, learning, and persistence". Dweck distinguishes between a fixed mindset and a growth mindset. A fixed mindset is the view that intelligence is static and cannot be changed, while a growth mindset believes that abilities can be developed through continuous learning and practice (Yohanes et al., 2025; Campbell et al., 2020). Research shows that a growth mindset can increase learning motivation, perseverance, and the ability to overcome challenges in learning. By having a growth mindset, students will be better prepared to face challenges in the STEAM learning process, which is full of exploration and problem-solving processes. Therefore, the development of teaching materials that not only facilitate STEAM-based learning but also foster a growth mindset becomes very important. The use of STEAM-based Flipped-Books is expected to be a solution to increase students' growth mindset in Science learning. In addition, one innovative learning media that supports this is the flipped-book, which is an interactive teaching material that allows students to learn independently before face-to-face activities, so that the learning process in class can be focused on in-depth problem-solving and discussion (Purnamatati et al., 2023).

The rapid development of science and technology in the 21. st century requires students to develop advanced thinking skills, adaptability, and the ability to solve problems creatively. In this context, nurturing a growth mindset, as introduced by Carol Dweck, becomes essential in shaping students who believe that intelligence and abilities can be developed through effort, perseverance, and effective learning strategies (Herlina et al., 2024). However, many elementary school students still demonstrate a fixed mindset, such as fear of making mistakes, lack of confidence, and reluctance to explore new learning approaches. These conditions indicate the need for innovative learning resources that can cultivate positive learning attitudes from an early age. This research is expected to provide benefits, both theoretically and practically. The theoretical benefits include contributions to the development of STEAM-based learning theory and its application in elementary school Science learning, as well as adding to the scientific knowledge in the field of interactive technology-based learning media development, especially digital flipped-books. Practically, for teachers, this research is expected to provide an alternative teaching material that is interesting, innovative, and easy to use in Science learning, and help teachers foster a growth mindset in students through an interactive and enjoyable approach (Olsson, 2020). For students, this research is expected to help increase students' active involvement in the learning process, facilitate independent learning, and foster a growth mindset through a learning experience integrated with the STEAM approach. For schools, this research can be a reference in developing digital learning media that supports the implementation of the Merdeka Curriculum and differentiated learning. Finally, for other researchers, this research can be a reference and basis for further research that wants to develop digital teaching materials or explore the STEAM approach in other subject areas.

Methods

The research sample was students of SD Negeri 22 Banda Aceh with details of 17 females and 8 males with a total number of 25 students. The 4D model, namely (Define, Design, Develop, Disseminate) consists of several sequential stages (**Figure 1**) (Creswell & Creswell, 2017). The first, Define namely analyzing Needs and Data Collection: This initial stage involves identifying existing problems in science learning, analyzing the characteristics of fourth-grade elementary school students, and collecting information about current teaching practices and available learning resources. This is done through observation, interviews with teachers and students, and analysis of existing curriculum documents. Design means product design based on the needs analysis, a STEAM-based flip book design is conceptualized. This includes defining content, selecting appropriate STEAM integration strategies, designing interactive elements, and determining the layout and visual aesthetics of the flip book. The last is Develop which begins by validating the product with Expert Validation.

The flipbook design then underwent rigorous validation by experts in various fields, including subject matter experts (science content and STEAM integration), media experts (digital media design and interactivity), and pedagogy experts (elementary education and growth mindset theory) and linguists to ensure the language used was based on the validity used. This validation process aimed to assess the validity and appropriateness of the developed material through an expert assessment questionnaire. This dissemination was the feedback and recommendations from the expert validation, and necessary revisions and improvements were made to the flipbook design to improve its quality and relevance. Through limited pilot testing, the revised flipbook was then piloted with a small group of fourth-grade students in a real classroom setting to gather initial feedback on its usability, clarity, and engagement. Extensive testing is done after a successful limited pilot test and further revisions, the flipbook was implemented with a larger group of students to assess its practicality and initial effectiveness in a more representative context. Final product revision is based on comprehensive data collected

from the wider pilot test, final refinements were made to the flipbook to produce a definitive version of the teaching material.

The data collection methods for this study include observation checklists to assess classroom interactions and student engagement, interview guides for in-depth insights from teachers and students, questionnaires (using a Likert scale) to evaluate student responses to the flipped-book's ease of use and appeal, and pre-test/post-test assessments to measure the impact on students' growth mindset. Qualitative data, gathered from observations, interviews, and open-ended questionnaire responses, will be analyzed descriptively to identify themes, patterns, and specific feedback. Quantitative data, derived from the Likert scale questionnaires and pre-test/post-test scores, will be analyzed using descriptive statistics (e.g., mean, standard deviation) to describe student responses and N-Gain score tests to determine the increase in students' growth mindset. The success indicators for this research are defined as follows: the product's feasibility must achieve a validation score of at least 61% from experts; the product's practicality will be determined by positive responses from teachers and students, with at least 75% of students reporting ease of use; and the product's effectiveness will be demonstrated by an increase in post-test scores with an N-Gain score of ≥0.3, indicating a medium to high effect on the development of students' growth mindset. Design Process in the chart:

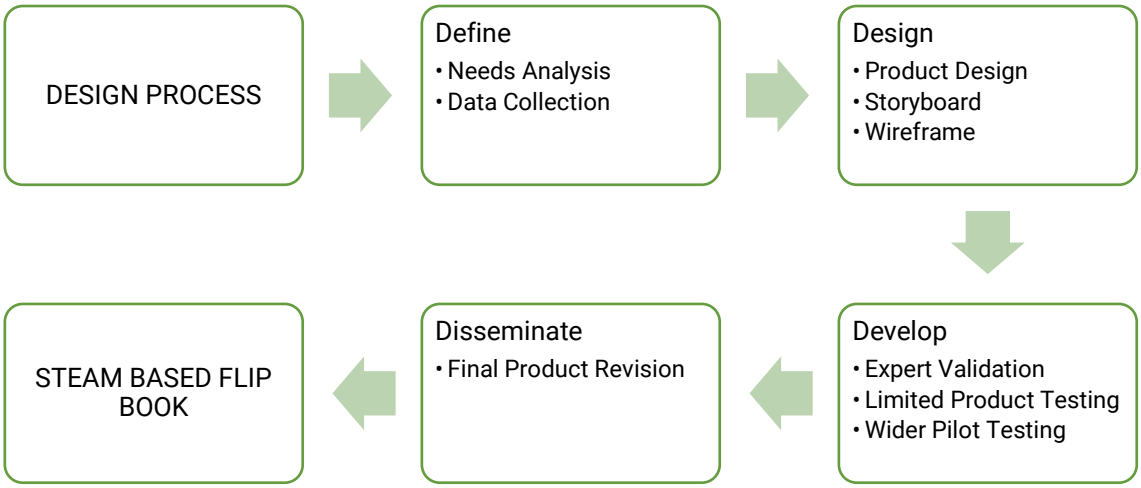

Figure 1. Design Process

Result and Discussion

Product Design Description of the STEAM-Based Flipped Book

The design of the STEAM-based flipped book in this study was systematically developed to support the cognitive, affective, and psychomotor needs of fourth-grade elementary school students. The product integrates multimedia elements, interactive learning components, and STEAM-based instructional strategies to create an engaging, student-centered digital learning resource. This design not only focuses on content accuracy and curriculum alignment but also incorporates pedagogical principles that promote a growth mindset. The following description outlines the major aspects of the product design. The design of the STEAM-based flipped book reflects a comprehensive approach to modern digital pedagogy. The integration of STEAM domains, interactive multimedia components, and growth mindset principles supports both academic achievement and character development. The combination of pre-class digital learning and in-class collaborative activities promotes deeper engagement, improved comprehension, and stronger metacognitive skills.

Product Validity

The STEAM-based flipped book developed in this study underwent a rigorous and multidimensional validation process conducted by experts in science education, STEAM integration, digital media design, pedagogy, and linguistics. The overall validity score of 87%, categorized as highly valid, reflects the strong alignment between the product's components and the standards expected for instructional materials at the elementary school level. This high score indicates that the flipped book successfully integrates content accuracy, pedagogical appropriateness, and multimedia quality. From the perspective of science content, experts confirmed that the concepts presented in the flipped book are scientifically correct, up to date, and relevant to the Grade 4 curriculum. The material supports conceptual understanding by incorporating simple

explanations, age-appropriate examples, and real-world STEAM applications. This ensures that students not only memorize content but also understand how scientific knowledge connects to everyday life an essential component of STEAM based learning. In terms of STEAM integration, the product was evaluated on how well it connects the five STEAM domains (Science, Technology, Engineering, Arts, and Mathematics). Experts noted that the flipped book effectively embeds these domains through inquiry-based activities, problem-solving tasks, and hands-on exploration. The integration was considered balanced, meaning that no single domain dominates the learning experience, but instead, students engage in interdisciplinary thinking. This aligns with the goal of STEAM education, which encourages creativity, collaboration, and critical thinking, ultimately supporting the development of a growth mindset.

The media design and interactivity were also highlighted as strengths. Experts in digital media design assessed the layout, navigation, use of colors, visual elements, and interactive features embedded in the flipped book. The design was deemed supportive of student engagement and comprehension. Visual elements such as diagrams, animations, and icons were carefully selected to reduce cognitive load and enhance clarity. The interactive components such as embedded videos, clickable sections, and reflective questions were found to encourage active learning. These design choices align with multimedia learning principles, which emphasize the importance of combining text, visuals, and interactivity to improve student understanding. From a pedagogical standpoint, the flipped book was validated for its alignment with student-centered learning principles and the flipped classroom model. Experts noted that the structure of the flipped book allows students to explore foundational material before class and engage more deeply in STEAM activities during class time. This approach supports mastery learning and encourages students to take responsibility for their learning process. Furthermore, the inclusion of reflection prompts, challenge tasks, and feedback-oriented activities aligns with growth mindset theory, which emphasizes effort, persistence, and continuous improvement.

Finally, linguistic experts evaluated the clarity, readability, and appropriateness of the language used. The results showed that the language level was well-suited for fourth-grade students, with simple sentence structures, familiar vocabulary, and clear instructions (**Table 1**). The linguistic clarity contributes significantly to the product's accessibility, ensuring that students with varying levels of reading ability can engage meaningfully with the content. Overall, the high validity score of the STEAM-based flipped book demonstrates its effectiveness as a well-designed instructional resource that integrates content, pedagogy, and technology. The positive expert feedback underscores the product's potential to enhance learning experiences, support curriculum goals, and foster a growth mindset among elementary school students. The robust validation process also strengthens the product's credibility, ensuring that it meets academic, developmental, and technological standards essential for high quality educational materials.

Table 1. Validity of Data

Validation Aspect	Indicators Evaluated	Validator Score (%)	Category
Science Content Validity	Content accuracy, curriculum alignment, real-world relevance, conceptual clarity	88%	Highly Valid
STEAM Integration Validity	Balance of 5 STEAM domains (S–T–E–A–M), interdisciplinary alignment, inquiry/problem-solving activities	86%	Highly Valid
Media Design & Interactivity Validity	Layout design, visual clarity, navigation, multimedia elements, cognitive load, interactivity	89%	Highly Valid
Pedagogical Validity	Student-centered approach, flipped classroom alignment, learning sequence, reflection, mastery orientation	87%	Highly Valid
Linguistic Validity	Readability, vocabulary level, clarity of instructions, sentence structure appropriateness	85%	Highly Valid
Overall Validity Score		87%	Highly Valid

Product Practicality

The practicality of the STEAM-based flipped book was evaluated through a systematic process involving both limited and broader implementation trials in a real classroom setting with fourth-grade students at SD Negeri 22 Banda Aceh. The goal of the practicality assessment was to determine whether the flipped book could be easily used, understood, and integrated into classroom learning without creating additional burdens for teachers or students. The practicality instrument consisted of student and teacher questionnaires developed using a Likert scale (Very Practical, Practical, Less Practical, Not Practical). The indicators assessed

included ease of use, clarity of instructions, visual design, interactivity, accessibility, and engagement. These indicators align with theoretical standards for evaluating digital learning media, particularly multimedia-based resources used in flipped learning environments. The results showed that the flipped book achieved a practicality score above 80%, which meets the minimum criteria and places it in the "Highly Practical" category (**Table 2**). This score reflects strong user acceptance and confirms that the flipped book provides intuitive navigation, appealing visuals, clear language, and engaging STEAM-related activities that facilitate students' understanding. From the students' perspective, the flipped book was considered easy to operate, even for those with limited digital literacy. The visual layout, supported by icons, illustrations, and multimedia elements, helped reduce cognitive load and enabled students to follow instructions independently during the pre-class phase. Students also expressed excitement and motivation when interacting with integrated videos, illustrations, and simple animations, demonstrating that the resource successfully increased engagement. Meanwhile, teachers reported that the flipped book significantly streamlined the learning process, especially in the preparation phase of the flipped classroom model (**Table 3**). Since students could explore basic concepts before class, teachers found that classroom activities became more efficient, allowing more time for deeper inquiry and hands-on STEAM activities. Teachers also emphasized that the flipped book promoted student collaboration during group work and supported differentiated learning, as students with varying abilities could learn at their own pace. These combined findings confirm that the flipped book is not only feasible for classroom use but also enhances the overall teaching–learning experience (**Table 4**). Its practicality is strengthened by the alignment of content, design clarity, and the successful integration of STEAM elements into an interactive digital format. The results of the practical data are explained in the following table.

Table 2. Practicality Test Results of the STEAM-Based Flipped Book (Student Responses)

No	Indicator	Max Score	Obtained Score	Percentage (%)	Category
1	Ease of navigation	100	84	84%	Highly Practical
2	Clarity of instructions	100	82	82%	Highly Practical
3	Visual attractiveness	100	85	85%	Highly Practical
4	Multimedia interactivity	100	81	81%	Highly Practical
5	Support for STEAM understanding	100	80	80%	Practical
6	Engagement and motivation	100	83	83%	Highly Practical
—	TOTAL	600	495	82.5%	Highly Practical

Table 3. Practicality Test Results (Teacher Responses)

No	Indicator	Max Score	Obtained Score	Percentage (%)	Category
1	Ease of implementation	20	17	85%	Highly Practical
2	Clarity of learning flow	20	16	80%	Practical
3	Support for flipped classroom	20	17	85%	Highly Practical
4	Facilitation of collaborative learning	20	16	80%	Practical
5	Improvement of learning efficiency	20	17	85%	Highly Practical
—	TOTAL	100	83	83%	Highly Practical

Table 4. Pre-test and Post-test Results of Students' Learning Outcomes

Parameter	Score
Average Pre-test	56.9
Average Post-test	83.8
Average Gain Score	26.9
Percentage Improvement	47.3%
Effectiveness Category	High Effectiveness

The development of a STEAM-based flipped book using the 4D model (Define, Design, Develop, Disseminate) demonstrated strong feasibility, practicality, and effectiveness in supporting elementary students' growth mindset and engagement in STEAM learning (Novelina et al., 2023). The design stage successfully produced a structured and visually engaging digital learning resource, as illustrated by the flowchart. The flowchart reflects a systematic and iterative development cycle, emphasizing the importance of expert validation and field trials in refining the product until it meets learning needs (Supriana et al., 2023). The modern science paradigm emphasizes that science learning is oriented not only toward mastering concepts, but also

toward the scientific process, problem-solving, interdisciplinary collaboration, and the application of knowledge in real-world contexts (Supriana et al., 2023). In this paradigm, science is viewed as a dynamic process, not simply a collection of facts that develop through observation, experimentation, creativity, and engineering. The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach aligns perfectly with this science paradigm because it integrates multiple disciplines to help students understand the world through a scientific and creative lens. Creative teachers prioritize a growth mindset, which needs to be developed in students because it is an essential foundation in modern education, which views abilities as something that can be developed (Purnamaningsih et al., 2023). In STEAM-based science learning, a growth mindset develops naturally through continuous experimentation, design, innovation, and reflection. Students not only understand scientific concepts but also develop a positive attitude toward learning, resilience, and the belief that effort can change outcomes. Elementary school students' mindsets are still developing and are heavily influenced by the learning experiences they receive. They need concrete, visual, collaborative, and exploratory learning, such as STEAM and flipped books, to foster healthy cognitive development while fostering a growth mindset, curiosity, creativity, and scientific thinking skills. Elementary school students' mindsets significantly determine how they perceive challenges, interpret failure, and develop long-term learning skills. At elementary school age, children are in the concrete operational stage (Piaget's), a stage where they begin to think logically but still require visual support and real-world experiences. This stage is a golden opportunity to instill a growth mindset, the belief that abilities can develop through practice, new strategies, and perseverance.

Conclusion

The development of a STEAM-based flipped book using the 4D model (Define, Design, Develop, Disseminate) has demonstrated that this digital learning resource is valid, practical, and effective in cultivating a growth mindset among elementary school students. The validation results confirm that the flipped book meets the standards of content accuracy, pedagogical appropriateness, linguistic clarity, and multimedia quality. These findings indicate that the product is suitable for supporting STEAM-based instruction and aligns well with the cognitive and developmental needs of Grade 4 learners. The practicality assessment further supports the usability of the product, with a score exceeding 80%, reflecting positive responses from both teachers and students. The flipped book was found to be easy to navigate, visually engaging, and supportive of pre-class preparation and collaborative learning activities. Its interactive features contribute significantly to student engagement, making it feasible for implementation in classroom settings. Effectiveness testing also revealed a meaningful improvement in student learning outcomes and mindset development. The improvement of students' learning outcome illustrates that the flipped book successfully enhances conceptual understanding, problem-solving skills, and students' willingness to embrace challenges core characteristics of a growth mindset. The STEAM-based flipped book developed in this study proves to be a high quality instructional tool that integrates content, pedagogy, and technology to create an engaging learning experience. This product has the potential to enrich STEAM education, promote independent and collaborative learning, and foster a growth mindset in elementary school students. Future research may expand implementation to a larger population, explore long-term impacts, and integrate more advanced interactive features to enhance the learning experience further.

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