

Digital Pop-Up Books Promote Meaningful Learning of Wave Concepts in Elementary Science Education

Siti Hanifah Khairun Nisa^{1*}, Tissa Laras Santi², Qori Ulil Qur'aini³, Hery Setiyawan⁴

^{1,2,3,4} Fakultas Keguruan dan Ilmu Pendidikan, Universitas Wijaya Kusuma, Indonesia

*corresponding author: Siti Hanifah Khairun Nisa hanifanisa27@gmail.com

ORCID

Hery Setiyawan <https://orcid.org/0000-0002-6710-0597>

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Abstract

The limited use of interactive learning media in elementary schools often hinders students' understanding of abstract concepts in Integrated Science and Social Studies (IPAS), particularly on the topic of waves. Therefore, this study aimed to develop a Digital Pop-Up Book learning media and determine its feasibility for fifth-grade elementary school students. This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The study involved 41 fifth-grade students and one teacher. Data were collected through interviews, observations, questionnaires, and documentation, while the product was validated by material, media, and language experts. The findings revealed that the Digital Pop-Up Book obtained feasibility scores of 89% from the material expert, 75% from the media expert, and 100% from the language expert. Field trials showed highly positive responses, with scores of 97% from the teacher and 90% from the students, indicating that the developed media was very feasible for classroom use. However, this study was limited to a single class and focused only on feasibility evaluation. The findings imply that Digital Pop-Up Books can serve as an alternative instructional medium to support IPAS learning, particularly for abstract topics requiring visual representation and interactive learning experiences.



Introduction

Education plays a crucial role in developing high-quality human resources capable of facing the challenges of an ever-changing era. In the implementation of the Merdeka Curriculum at the elementary school level, Integrated Science and Social Studies (IPAS) has been introduced as a subject designed to equip students with an understanding of natural phenomena and social life in an integrated manner. Through IPAS learning, students are encouraged to

understand the relationship between humans and their environment and to develop systematic and scientific ways of thinking. In addition to emphasizing conceptual understanding, IPAS aims to foster critical, analytical, and creative thinking skills, as well as problem-solving abilities needed in everyday life.

In the current elementary school curriculum, science and social studies have been integrated into a single subject known as Integrated

Science and Social Studies (IPAS) (Wijaya et al., 2023). According to (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025), the integration of science and social studies into IPAS represents an innovation in the development of the Indonesian curriculum. Previously taught as separate subjects, these disciplines are now combined to provide students with more contextual and meaningful learning experiences. The Merdeka Curriculum aims to cultivate students' curiosity, encourage active participation, develop inquiry skills, enhance self-awareness and environmental awareness, and deepen their understanding of scientific and social concepts. Furthermore, (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025) states that IPAS plays a significant role in developing scientific understanding, practical skills, and character values necessary to face increasingly complex global challenges, including climate change, health issues, social inequality, and environmental sustainability. Therefore, IPAS learning at the elementary level emphasizes the understanding of scientific concepts and processes and encourages students to think critically, analytically, and creatively when solving problems.

Despite its importance, the effectiveness of IPAS learning is highly influenced by the availability and utilization of appropriate learning media. Learning activities that lack instructional media often cause students to become bored and lose interest in learning. (Ilham et al., 2024) reported that learning difficulties experienced by students are influenced by various factors, including poor physical conditions, declining learning attitudes, reduced learning motivation, inadequate instructional media, limited infrastructure, unfavorable home environments, and insufficient understanding of curriculum implementation. Similarly, (Maharani et al., 2025) found that students' learning difficulties are caused by less varied teaching methods, limited use of interactive learning media, and school conditions that do not fully support effective learning. These

factors ultimately contribute to low learning outcomes and students' inability to achieve the Minimum Completeness Criteria (KKM).

Learning media serve as important tools in facilitating students' understanding of learning materials. According to (Ucha Jr et al., 2024), instructional media are essential for delivering learning materials effectively and helping students understand concepts more easily. In the context of the Merdeka Curriculum, learning media also promote active student participation and function as valuable learning resources. (Tubagus, 2025) defines learning media as tools that support learning activities and improve their effectiveness and efficiency, including visual, audio, and audiovisual media. In this rapidly developing digital era, learning media have become an important component in increasing students' learning motivation and improving the quality of the teaching and learning process (Ruslan & Muliana GH, 2025).

Among the various types of instructional media, pop-up books have proven to be effective in attracting students' attention. (Sinta & Syofyan, 2020) define pop-up books as three-dimensional books containing illustrations and texts that can move through folding techniques, thereby creating engaging learning experiences. Likewise, (Yudiana et al., 2024) describes pop-up books as learning media with three-dimensional visual elements and interactive features that provide interesting visualizations for students. According to Zahro (2016, as cited in (Kamal et al., 2024), pop-up books possess several advantages, such as overcoming limitations of time and space, presenting objects more realistically than verbal explanations, accommodating various age groups, and making reading activities more enjoyable through their three-dimensional design.

Although pop-up books offer numerous benefits, their use in learning activities remains relatively limited. Previous studies have demonstrated the positive effects

of pop-up books on students' learning. (Eliasar & Astuti, 2023) found that pop-up books can increase students' learning interest, while (Winda et al., 2022) reported improvements in learning outcomes. (Yufrizal et al., 2024) revealed that pop-up books can enhance reading interest, whereas (Triana et al., 2025) found that they promote students' active participation during learning activities. Furthermore, (Wulandari, 2022) demonstrated that pop-up books contribute to the development of students' critical thinking skills. Based on interviews conducted on May 22, 2026, with Mrs. Indah, S.Pd., the fifth-grade homeroom teacher at SD Rahmat, Sawahan District, Surabaya, East Java, it was found that the school had implemented the Merdeka Curriculum. However, learning facilities, particularly instructional media supporting IPAS learning, are still limited. According to the teacher, the topic of waves is considered difficult for students because it encompasses broad scientific concepts and requires strong memory retention. Students tend to understand the material more easily when it is presented through visually attractive and concrete objects. In practice, classroom instruction still relies heavily on teacher guidebooks, while the use of innovative instructional media remains minimal. Consequently, students require a longer time to understand the material, indicating the need for more creative and engaging learning media.

In response to these problems, this study aims to develop a Digital Pop-Up Book as an innovative learning medium for wave materials in Integrated Science and Social Studies (IPAS). The use of pop-up books is considered appropriate because their three-dimensional and interactive design enables students to visualize abstract concepts more concretely and meaningfully. Previous research conducted by (Mogi et al., 2025) developed pop-up book learning media for the solar system topic in IPAS for fifth-grade students at SDI Mengeruda. However, the present study differs in terms of learning materials, research subjects, and the

application of the ADDIE development model within the context of topic-based IPAS learning integrated with the Merdeka Curriculum. Therefore, the development of a Digital Pop-Up Book on wave materials is expected to provide an alternative solution to the limited availability of instructional media at SD Rahmat, Sawahan District, Surabaya, and contribute to improving the quality of IPAS learning, students' interest in learning, and their understanding of wave concepts in a more effective and meaningful manner.

Method

This study employed a Research and Development (R&D) approach. The development model adopted in this study was the ADDIE model, which consists of five stages: Analyze, Design, Development, Implementation, and Evaluation. During the analysis stage, the researchers identified the needs for Pop-Up Book learning media by conducting a needs assessment involving teachers, curriculum requirements, and students' characteristics. Subsequently, the design stage focused on preparing the initial framework or prototype of the Pop-Up Book learning media to be developed.

The next stage, namely development, involved producing the designed media and assessing its feasibility through validation conducted by subject matter experts, media experts, educational practitioners, and limited trials involving a small group of students. In addition, revisions and improvements to the media were carried out based on suggestions and feedback provided by the validators, practitioners, and students participating in the preliminary trials. Upon completion of the development process, the Pop-Up Book learning media was implemented on a larger scale during the implementation stage. At this stage, the media was utilized in learning activities while simultaneously collecting students' responses toward the developed product. The final stage, evaluation, was conducted to review the entire process, beginning from the analysis stage to the

implementation stage, in order to determine the quality and effectiveness of the developed Pop-Up Book learning media (Mulyasari & Doly, 2023).

This study was conducted at SD Rahmat, located in Sawahan District, Surabaya, East Java. The participants of the study were 41 fifth-grade elementary school students. The selection of the research site was based on the need to develop instructional media that corresponded to the school's conditions. Based on observations and interviews with the fifth-grade teacher, it was found that the utilization of learning media during classroom instruction remained limited and lacked variation. Furthermore, the teacher reported that the topic of waves in Integrated Science and Social Studies (IPAS) was considered difficult for students due to its broad scope and the need for strong memory retention. Therefore, the development of an engaging and meaningful learning medium was considered necessary to facilitate students' understanding of the material. Data were collected through interviews, observations, questionnaires, and documentation. Interviews and observations were conducted during the needs analysis stage to obtain information regarding classroom conditions and the challenges encountered by teachers and students. Questionnaires were used to collect validation data from experts as well as responses from teachers and students toward

the developed learning media. Documentation was employed to support and complement the research data.

The validation process involved subject matter experts, media experts, and language experts who possessed expertise in their respective fields. In addition, the product evaluation involved the fifth-grade teacher as an educational practitioner and the students as end users of the media. Data analysis techniques consisted of both quantitative and qualitative descriptive analyses. Qualitative data in the form of comments and suggestions from validators were analyzed descriptively and used as the basis for product revision. Meanwhile, quantitative data obtained from validation sheets and response questionnaires were analyzed using percentage calculations to determine the feasibility level of the developed learning media.

Quantitative data obtained from validation sheets and response questionnaires were analyzed using percentage calculations to determine the feasibility level of the developed learning media. The percentage scores were interpreted based on predetermined feasibility criteria. A score ranging from 81% to 100% was categorized as "very feasible," 61% to 80% as "feasible," 41% to 60% as "fairly feasible," 21% to 40% as "less feasible," and 0% to 20% as "not feasible."

Table 1. Feasibility Criteria

Percentage (%)	Interpretation
81-100	Very Feasible
61-80	Feasible
41-60	Fairly Feasible
21-40	Less Feasible
0-20	Not Feasible

Results

This study was conducted by employing the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model as the framework for developing the learning

media. The selection of this model was based on its systematic and comprehensive characteristics, which facilitate the development of instructional media that effectively address students' learning needs. Through the stages of the ADDIE model, a

Pop-Up Book learning media product was successfully developed for the topic of waves in Integrated Science and Social Studies (IPAS) for fifth-grade elementary school students.

Table 2. Expert Validation Results of the Digital Pop-Up Book Learning Media

Validator	Score (%)	Category
Material Expert	89	Very Feasible
Media Expert	75	Feasible
Language Expert	100	Very Feasible

To determine the feasibility of the developed product, a validation process was carried out by several experts according to their respective fields of expertise. The results of the material expert validation indicated that the learning media obtained a score of 89%, which was categorized as "very feasible." Meanwhile, the media expert assigned a score of 75%, placing the product in the "feasible" category. Furthermore, the language expert evaluation yielded a perfect score of 100%, which was also classified as "very feasible." Based on these validation results, the Pop-Up Book learning media met the required feasibility criteria and was considered suitable for further testing through field implementation.

Table 3. Result of Field Trial Evaluation

Respondent	Score (%)	Category
Fifth-Grade Teacher	97	Very Feasible
Students	90	Very Feasible

The field trial was conducted at SD Negeri Jangrana and involved one fifth-grade teacher and all students in the class. According to the teacher's evaluation, the developed learning media received a score of 97%, which fell into the "very feasible" category. In addition, the overall responses from the students resulted in a score of 90%, which was likewise categorized as "very feasible." These

findings indicate that the developed Pop-Up Book learning media possesses a high level of feasibility and can be effectively utilized to support the teaching and learning process of Integrated Science and Social Studies (IPAS), particularly on the topic of waves for fifth-grade elementary school students.

Discussion

The findings of this study demonstrate that the Digital Pop-Up Book developed for the topic of waves in Integrated Science and Social Studies (IPAS) achieved a high level of feasibility based on expert validation and field testing. The material expert assigned a score of 89%, the media expert awarded 75%, and the language expert provided a score of 100%. In addition, the teacher and student responses reached 97% and 90%, respectively, indicating that the developed media was considered highly feasible for classroom implementation. These findings suggest that the Digital Pop-Up Book successfully met the criteria of content appropriateness, media design quality, and language suitability for elementary school learners.

The high score obtained from the material expert indicates that the content presented in the Digital Pop-Up Book was aligned with the learning objectives and curriculum requirements of IPAS. This finding is important because wave concepts are often perceived as abstract and difficult for elementary students to understand. The use of visual representations and interactive elements in the Digital Pop-Up Book may have helped transform abstract concepts into more concrete learning experiences. This finding supports the study of (Ansori et al., 2024) who reported that science-based digital pop-up books improved students' conceptual understanding and learning engagement. Similarly, (Ayuningtyas & Widodo, 2026) found that digital pop-up books facilitated students' comprehension of complex learning materials and contributed to better learning outcomes. These studies suggest that the integration of visual and interactive features can effectively support

elementary students' understanding of scientific concepts.

From a theoretical perspective, the effectiveness of the Digital Pop-Up Book can be explained through Dual Coding Theory proposed by Paivio. According to this theory, learning becomes more effective when information is presented through both verbal and visual channels. In the present study, wave concepts were delivered through written explanations accompanied by three-dimensional visualizations, allowing students to process information using multiple cognitive pathways. As a result, students may have been able to construct stronger mental representations of the concepts being learned. This explanation is consistent with the findings of (Yudiana et al., 2024), who emphasized that pop-up books provide meaningful visual experiences that enhance students' understanding and interest in learning.

The media expert's evaluation resulted in a score of 75%, categorized as feasible. Although lower than the scores provided by the material and language experts, this result still indicates that the media met acceptable quality standards. The lower score may reflect aspects related to design refinement, navigation, or technical features that could be improved in future developments. Similar findings were reported by (Fatmawati & Janattaka, 2025) who found that digital pop-up books generally achieved high validity but still required revisions in design and media presentation before broader implementation. Therefore, the present study confirms that instructional media development is an iterative process that benefits from continuous evaluation and improvement.

The language expert provided a score of 100%, indicating that the language used in the Digital Pop-Up Book was fully appropriate for elementary school students. Language plays a critical role in determining the effectiveness of instructional materials because students at the elementary level require simple, clear, and age-appropriate

explanations. This finding supports previous studies by (Sinta & Syofyan, 2020) and (Eliasar & Astuti, 2023) which highlighted the importance of understandable language in enhancing students' engagement with pop-up book media. Clear language reduces cognitive burden and allows students to focus more effectively on understanding scientific concepts.

The positive responses from teachers and students further demonstrate the practicality of the developed media. The teacher response score of 97% suggests that the Digital Pop-Up Book was perceived as useful, relevant, and easy to integrate into classroom instruction. This finding is consistent with (Rosyada et al., 2025) who found that teachers viewed digital pop-up books as effective tools for creating more interactive and student-centered learning environments. Likewise, (Trisna et al., 2025) reported that combining conventional pop-up elements with digital features increased classroom engagement and facilitated learning activities.

The student response score of 90% indicates that learners found the media interesting and enjoyable to use. Student engagement is an important indicator because learning motivation strongly influences academic achievement. Previous studies conducted by (Winda et al., 2022), (Yufrizal et al., 2024), and (Agustin et al., 2026) similarly reported that pop-up book media increased students' learning motivation, reading interest, and classroom participation. The findings of the present study therefore strengthen existing evidence that interactive visual media can positively influence students' attitudes toward learning.

The results of this study are also closely related to the objectives of the Merdeka Curriculum, which emphasizes active learning, inquiry, critical thinking, and meaningful learning experiences. According to (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025) IPAS learning is intended to encourage students to

actively explore scientific and social phenomena rather than merely memorize information. The Digital Pop-Up Book developed in this study supports these objectives by providing opportunities for students to interact with learning content through visual exploration. This finding aligns with (Ucha Jr et al., 2024). Although the findings are generally consistent with previous studies, several distinctions can be identified. Most earlier studies focused on topics such as the solar system, cultural diversity, water cycles, or social studies content. For example, (Indrawatiningsih et al., 2024) developed a pop-up book for learning the solar system, while (Edu et al., 2026) focused on regional culture in social studies learning. In contrast, the present study specifically addressed wave concepts, which involve abstract scientific phenomena that cannot always be directly observed by students. Therefore, this study extends existing literature by demonstrating that digital pop-up books can also be effectively applied to abstract science-related concepts within IPAS learning.

Another important contribution of this study lies in the use of the ADDIE model as a systematic framework for instructional media development. The stages of analysis, design, development, implementation, and evaluation enabled the researchers to identify learning needs and continuously improve the product based on expert feedback. Similar conclusions were reached by (Dahlia et al., 2026), who reported that the ADDIE model facilitated the development of valid and practical instructional media. Thus, the findings reinforce previous evidence regarding the suitability of ADDIE for educational media development.

From a practical perspective, the developed Digital Pop-Up Book offers teachers an alternative instructional medium that can help overcome limitations in existing learning resources. The media can be used to support the teaching of abstract concepts and create more engaging learning environments. From a theoretical perspective, this study contributes

to the growing body of literature concerning technology-based instructional media and demonstrates the potential of combining digital elements with three-dimensional visualization to support elementary education. Consequently, the findings provide additional evidence that innovative media can enhance the quality of learning experiences in the implementation of IPAS within the Merdeka Curriculum.

Conclusion

This study aimed to develop a Digital Pop-Up Book for teaching wave concepts in Integrated Science and Social Studies (IPAS) and to evaluate its feasibility for use in elementary school classrooms. The findings revealed that the developed media met the established feasibility criteria based on evaluations from material, media, and language experts, as well as positive responses from teachers and students. These results indicate that the Digital Pop-Up Book is an appropriate instructional medium for supporting the learning of wave concepts, which are often considered abstract and challenging for elementary school students. The findings further suggest that integrating three-dimensional visualization and digital elements can enhance the attractiveness and practicality of learning media. The developed Digital Pop-Up Book supports the implementation of student-centered learning promoted by the Merdeka Curriculum by providing more interactive and meaningful learning experiences. Therefore, this study contributes to the growing body of research on technology-based instructional media and extends previous studies by demonstrating the applicability of Digital Pop-Up Books for science-related concepts in IPAS learning. Despite these contributions, several limitations should be acknowledged. First, the study involved only one class of fifth-grade students, which limits the generalizability of the findings. Second, the study focused solely on determining the feasibility of the developed media and did not examine its effectiveness in improving learning outcomes through

experimental methods. Third, the media was developed specifically for wave concepts, which may limit its applicability to other learning topics. Future research is therefore recommended to involve larger and more diverse samples, apply experimental or quasi-experimental designs, and explore the implementation of Digital Pop-Up Books across different topics and educational contexts.

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Conflicts of Interest

This research is conducted to provide information to the public regarding the research that has been conducted so that it can be used for educational purposes. In addition, this research is used by researchers for lecturer

performance loads and accreditation needs of study programmes and institutions

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