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Exploring Natural Phenomena with Pop-Up Books: A Tool for Early Science Literacy

Abstract

The introduction of science literacy to early childhood is still limited. The books available to support science literacy are often non-interactive and less engaging for children. This causes children to become passive and less interested, as science learning is often conducted through lectures without challenging activities or visualizations. This requires learning media that can enhance science literacy in early childhood. This study aims to develop and validate a pop-up book based on natural phenomena designed to enhance science literacy in early childhood. This research uses the Research and Development (RnD) method of the Borg & Gall model through 6 stages, namely initial information gathering, product design, product validation, product revision, limited product testing, and product results. The data collection technique uses questionnaires to validate the product by material experts, media experts, language experts, and 5 users assessments, with data analysis using percentages. The research results indicate that the nature based Pop-up Book media can be used to improve science literacy in early childhood. Based on user assessments by principals and teachers, the nature based Pop-up Book media was able to increase science literacy by 95.83% with the criteria of being feasible to use. This finding shows that science literacy in early childhood is a fundamental foundation for building children's understanding of the universe as well as developing their critical thinking skills and curiosity. Therefore, this media can serve as an engaging, effective, and interactive alternative learning media to introduce scientific concepts contextually to young children.

Introduction

Introducing science to early childhood is very important because through direct interaction with nature, children will gain valuable experiences that can form the foundation of their knowledge and life skills in the future. This is in line with Bybee's statement that science literacy should be introduced from an early age (Bybee, 2008). Through science literacy, early childhood children are expected to be able to ask questions, explore, and express answers to various questions that arise from their strong curiosity about everything around them (Avikasari et al., 2018). Children's high curiosity is a great potential that can be directed through the habituation of scientific attitudes and ways of thinking. This enables children not only to be interested in what happens around them, but also to understand, explore, and respond to it logically and in accordance with reality. Thus, from an early age, children can begin to develop critical thinking, objectivity, and evidence-based reasoning, which are essential for their intellectual development in the future. Science literacy in early childhood aims to introduce facts and phenomena

occurring in the surrounding environment, so that the knowledge gained can serve as a useful foundation for the child's life and development in the future (Zahro et al., 2019). Moreover, learning science literacy can also foster honesty and wisdom in children as they face and solve various problems (Sholeha et al., 2021). Based on the results of the 2022 (Noor, 2020) Program for International Student Assessment (PISA), Indonesia experienced a decline in scores across all subjects mathematics, reading, and science compared to 2018. The average science literacy score for Indonesia in PISA 2022 was 383, down from 396 in PISA 2018 (https://www.issed.id/). Nevertheless, Indonesia's ranking showed a slight improvement compared to the previous edition. Indonesia's ranking in science literacy in PISA 2022 rose by 6 positions compared to PISA 2018, despite the decrease in the average score (https://www.polibatam.ac.id). Overall, Indonesia ranked 66th out of 81 participating countries in PISA 2022, with an average science literacy score of 383. This score remains far below the average of the member countries of the Organisation for Economic Co-operation and Development (OECD), which is 485. This fact indicates that although there is a slight improvement in ranking, the quality of science literacy in Indonesia still requires serious attention and continuous efforts for improvement (The Condition of Education 2024). One of the reasons for the lack of science literacy introduction in early childhood is the limited learning media used by teachers, who still heavily rely on conventional methods such as lectures and textbooks. In fact, young children need concrete, visual, and interactive approaches to better understand scientific concepts. The lack of diverse media such as teaching aids, educational videos, simple experiments, and science-based games—along with insufficient teacher training, further worsens the situation. As a result, science learning becomes less engaging and fails to stimulate children's curiosity. Therefore, serious efforts are needed to provide adequate learning media and to enhance teachers' competencies so that science learning can become more effective and meaningful.

According to De Boer, scientific literacy is defined as the ability to understand science in a meaningful way, enabling individuals to apply it in their daily lives (Cahyana et al., 2019). This statement aligns with Ayu's view, which states that scientific literacy is a part of lifelong education, making it a competency that is continuously needed throughout a person's life. This is because science is always present in every aspect of daily life for all living beings. Therefore, scientific literacy becomes an essential learning subject to be introduced and taught from an early age, so that children develop a strong understanding and are able to apply scientific principles when facing various situations in their future lives (Ayu et al, 2021). This is in line with Gerde's opinion, which states that early childhood is the ideal period to engage children in scientific activities. At this stage, children possess a high level of curiosity and strong exploratory abilities, making it a crucial time to foster their interest and understanding of science. One effort to enhance scientific literacy in children is through the use of instructional media. Learning media plays a vital role

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in the teaching and learning process, as it helps teachers convey information in ways that are more engaging, concrete, and easily understood by young learners. With the right media, abstract scientific concepts can be transformed into enjoyable and meaningful learning experiences (Gerde et al., 2018).

The issue of limited science literacy highlights the need to develop innovative learning media. Science is closely related to real-world events and phenomena in the surrounding environment, making it essential to present learning experiences that are contextual and relevant to daily life. Through science literacy, children become more aware of and sensitive to events happening around them (ZR & Eliza, 2020). Therefore, it is important to create learning media that provide a realistic and enjoyable experience, spark curiosity, and help children engage more deeply with scientific concepts.

Learning media play a vital role as tools that help clarify the intentions and objectives of learning delivered by teachers to young children (Hasan, 2021). Therefore, selecting appropriate media is crucial, especially in introducing science literacy from an early age. One effective medium for this purpose is the *pop-up book*. When teachers are able to properly introduce and teach science literacy, it lays a strong foundation for scientific understanding in early childhood (Sholeha et al., 2021). The *pop-up book* is chosen because of its various advantages. As stated by Van Dijk, it can convey complex content through engaging visual illustrations. This not only helps children comprehend and retain information more easily but also increases their interest and encourages active participation in the learning process (Nikmah et al., 2019). Thus, the *pop-up book* serves as an effective learning strategy to foster science literacy in early childhood.

A *pop-up book* is a three-dimensional visual medium that, when opened, reveals raised images, creating a realistic and lively impression of the presented material (Mustika & Ain, 2020). The engaging visuals on each page stimulate children's curiosity, encouraging them to explore the content while facilitating a more enjoyable and meaningful learning experience. In addition to its surprising visual elements that spark intrigue, a *pop-up book* can include interactive activities that actively involve children in the learning process. A study by Nikmah et al. (2019) demonstrated that using *pop-up books* in learning significantly improves children's learning quality. This is evidenced by a notable increase in post-test scores, which reached 90.37, compared to the pre-test score of 50. Based on these findings, it is highly plausible that *pop-up books* themed around natural phenomena could effectively enhance science literacy in early childhood education. (Nikmah et al., 2019). This study aims to examine the development process and evaluate the feasibility of a natural phenomena-based pop-up book as a learning medium designed to enhance science literacy in children aged 5 to 6 years.

Methods

This study employs the Research and Development (R&D) method, chosen because the product to be developed is a pop-up book media that can be systematically tested according to the development objectives, namely to enhance science literacy in early childhood. The R&D approach provides a structured framework for designing, developing, and testing the effectiveness of the media to ensure that the intended learning goals are achieved. According to Borg and Gall, developmental research is a systematic approach to designing, developing, and evaluating a product to ensure its suitability for educational use (Borg & Gall, 1983).

The development procedure for the *pop-up book* media based on natural phenomena in this study refers to the development model proposed by Borg and Gall, adapted using six out of the ten suggested steps. These steps include: (1) preliminary information gathering, (2) product design, (3) product validation, (4) product revision, (5) limited trial, and (6) final product. Sri Gustiani stated that the 10 steps of the Borg & Gall Model can be modified into 3-8 steps according to the needs of the research (Sri Gustiani, 2019). This simplification of the research stages was also carried out by the researcher due to limitations in time and budget. The data collection technique employed in this study was a questionnaire containing validation instruments assessed by expert validators. The questionnaire was given to 5 experts in the fields of media, language, early childhood education, and practitioners. The validators assessed the feasibility of the media based on the practicality, usage, and durability of the media. To evaluate the effectiveness of the media product, the researcher used an observation guide to assess children's science literacy, which includes the stages of contact, curiosity, concept formation, and concept acquisition. A questionnaire is a data collection technique that involves providing a series of written questions or statements to respondents to obtain responses relevant to the researcher's objectives (Saifuddin Azwar, 2010).

Data analysis was conducted quantitatively using percentage analysis techniques and was further explained through descriptive analysis to interpret the validation results and product feasibility testing. Percentage analysis was chosen to simplify the depiction and categorization of variables quantitatively. The feasibility of the media was determined based on assessments provided by expert validators and feedback from teachers as practitioners in the field.

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Result

The development of a natural phenomena based pop-up book began with an analysis of information related to the situations, conditions, and problems encountered in schools. Preliminary research conducted at several early childhood education (ECE) centres in Cirebon City revealed a limitation in the introduction of science literacy to young children. One causative factor was the lack of educational media specifically designed to introduce science. There is also a shortage of interactive and contextual books for introducing science to young children. Educational media play a crucial role in helping teachers convey information in a more engaging, concrete, and easily understood manner by children. Therefore, relevant, innovative, and age appropriate learning media are necessary to support the improvement of science literacy from an early age. The development of pop-up books is considered an appropriate solution for introducing science to young children because these books are relevant to early childhood themes, interactive, contextual, and easy to use.

The next step the researcher took was to develop a blueprint for the pop-up book, which included the learning content and an initial outline to be developed. This was followed by the design process of the pop-up book media, carried out together with a team to ensure the content met the needs of children in schools. The chosen theme focused on natural phenomena, specifically rain. The material was presented as a simple story intended to introduce children to the rainy season, the process of rain formation, and various events during rainy weather in daily life. This theme was selected based on field observations showing that teachers generally explain the concept of rain verbally without visual media assistance to help children understand the process concretely. As a result, children lack a clear visual representation of this natural phenomenon. This aligns with Mursid's view that science literacy for early childhood must align with the learning objectives stated in the applicable curriculum. In this context, the basic competencies of the 2013 Early Childhood Education Curriculum include the introduction of the natural environment, specifically the rain formation process, as one important topic that should be introduced from an early age (Zahro et al., 2019).

In implementing science literacy learning, the researcher adapted four of the six established stages of science literacy. These four stages are: 1) Contact Stage with two indicators: (a) children are able to recognize the rainy season, and (b) children are able to understand the process of rain formation; 2) Curiosity Stage with one indicator: children can describe the process of rain formation; 3) Concept Formation Stage where children are expected to sequence the stages of rain formation correctly; and 4) Decision-Making Stage consisting of two indicators: (a) children are able to write words related to rain (such as rain, cloudy clouds, sun, wind, and seawater), and (b) children are able

to select appropriate rain gear. Each stage is designed to support the development of scientific thinking skills in early childhood through engaging and meaningful learning experiences (Abidin et al., 2017).

1.1 Development of a Pop-Up Book Media Based on Natural Phenomena

The development of an educational media in the form of a pop-up book themed on natural phenomena was carried out through a series of validation stages to ensure the quality and feasibility of the product before implementation. The validation process involved three categories of experts: subject matter experts, media experts, and language experts. The subject matter and media validators were lecturers with backgrounds in Early Childhood Education, while the language validation was conducted by a lecturer specializing in the Indonesian language. The purpose of this validation process was to assess the feasibility of the content, design, and language used in the media product, as well as to gather constructive feedback and revision notes to improve and perfect the product. Through this validation phase, the developed pop-up book is expected to become more effective, engaging, and aligned with the characteristics and developmental needs of early childhood learners. Each expert provided their assessments using a questionnaire instrument that had previously undergone a validity test, ensuring the reliability and objectivity of the data collected. This process serves as a crucial step in developing educational media that is not only visually appealing but also educational and linguistically appropriate (Avirudini, 2018).

The validation process by the material expert was carried out in two stages to ensure the relevance and quality of the content in the developed pop-up book. The focus of the material expert's assessment covered the feasibility of the supporting learning materials and the integration of scientific literacy related to natural phenomena for early childhood learners. The first stage of validation resulted in a feasibility score of 80%, which falls into the "feasible" category. At this stage, the material expert provided several inputs and revision notes aimed at improving the content, particularly in terms of integrating learning materials with scientific literacy concepts appropriate for early childhood development. Based on these findings, the researcher revised and refined the media in accordance with the suggestions provided. The second stage of validation then achieved a feasibility percentage of 95%, which is categorized as "very feasible." Although the results showed a significant improvement, there was still one revision note from the material expert, namely the need to improve the introductory section of the children's writing activity. This feedback is considered an important point to further enhance the quality of the developed media so that it becomes more effective and aligned with the learning needs of early childhood education.

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In addition to validation by the material expert, the researcher also involved a media expert with the same academic background, namely Early Childhood Education. The media expert's validation focused on the visual appearance and physical durability of the developed *pop-up book* based on natural phenomena. The assessment was conducted in two stages using a questionnaire instrument previously developed by the researcher. In the first stage, the validation process by the media expert resulted in a feasibility percentage of 66.66%, which falls into the "fairly feasible" category. Based on these results, the media expert provided several suggestions and revision notes related to the visual design and durability of the media to better align with the characteristics of early childhood learners. Following this feedback, the researcher made the necessary improvements and refinements to the media. After the revisions were implemented, the second stage of validation was conducted, showing a significant improvement with a feasibility percentage of 95.83%, which is categorized as "feasible." The increase in scores from the first to the second stage indicates a substantial improvement in the quality of the developed *pop-up book* media. The media expert concluded that the product is ready to be tested with children, with only a few minor notes for further refinement. This suggests that the media is approaching a high level of quality and is ready for use in early childhood learning activities.

The final validation was carried out by a linguistic expert who is a lecturer with an academic background in Indonesian language studies. The focus of this assessment was on the linguistic aspects of the *pop-up book*, which were evaluated based on three main indicators: communicativeness, readability, and clarity of language use. The validation process by the linguistic expert was conducted in a single stage and resulted in a feasibility percentage of 87.5%, which falls into the "feasible" category. This result indicates that the language used in the media meets the required standards in terms of message clarity, ease of understanding for early childhood learners, and appropriateness of word choice. This assessment plays an important role in ensuring that the language used in the media is not only visually appealing but also supports the effective delivery of content in accordance with the linguistic development characteristics of young children. Based on these findings, the *pop-up book* media is considered feasible for use in educational settings, particularly from the linguistic perspective.

One of the strategic efforts to enhance science literacy in early childhood is through the use of appropriate learning media. Learning media serve as a bridge to transform abstract or complex subject matter into more concrete and easily understandable content for young children. This aligns with the view of Afrih Lia (2018), who states that learning media help explain materials that are difficult to grasp without the presence of symbols, representations, or supporting visualizations. The pop-up book is designed naturally with good visualization, so

that children learn more contextually, which can stimulate logical and critical thinking. Research results show that visual image-based teaching aids are effective in promoting visual-motor coordination and the integration of visual perception with cognitive development (Eördegh et al., 2022). The results indicate that at a younger age, watching (visual) is more effective than direct play under certain conditions (Schroeder & Kirkorian, 2016). The findings show better performance in a multisensory paradigm which includes visual as part of the stimuli (Lo & Wang, 2024).

Young children tend to comprehend information more effectively through visual stimuli rather than abstract explanations alone. Therefore, the presence of visually engaging media can significantly increase children's involvement in the learning process and strengthen their understanding of basic scientific concepts in a simple and meaningful way. In the context of early childhood science literacy, media should be able to guide children in understanding natural phenomena in a fun, contextual, and meaningful manner. Thus, learning media not only function as supportive tools but also serve as essential instruments in laying the foundation of scientific knowledge from an early age (Afrih Lia, 2018).

The *pop-up book* based on natural phenomena is an innovative form of visual learning media specifically designed for early childhood education. This media is developed in the form of a book that features three-dimensional (3D) images accompanied by simple narratives to explain the process of rainfall. The primary objective of developing this media is to enhance science literacy in young children, particularly in understanding natural phenomena such as rain. The selection of the *pop-up book* as a learning medium is based on the consideration that it serves as a bridge between real-life experiences and symbolic representations, making it easier for children to grasp abstract concepts. Blumel and Taylor (2012) state that *pop-up books* can be an effective tool for connecting children's real-world experiences with visual representations that are appropriate to their cognitive development stage(Blumel & Taylor, 2012). Through engaging visuals and language tailored to the linguistic abilities of young children, the *pop-up book* enables learners to understand the stages of the rain formation process gradually and contextually. This aligns with the perspective of Johnson and Lawson, as cited in Özgelen (2012), who emphasize that science education for early learners should introduce scientific processes, both in acquiring new knowledge and in understanding familiar natural phenomena such as rain (Özgelen, 2012). The advantage of this *pop-up book* on natural phenomena, compared to conventional *pop-up books*, lies in the integration of educational activities specifically designed to actively engage children. These activities not only increase the media's appeal but also enhance children's involvement in exploring science in a fun and meaningful way. Thus,

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this media is expected to serve as an effective instructional tool in building a solid foundation for science literacy from an early age.

1.2Feasibility of the Pop-Up Book Media Based on Natural Phenomena

The next step taken by the researcher after successfully developing the nature-phenomena-based pop-up book was to test its feasibility in improving science literacy among children aged 5–6 years. The feasibility test was conducted through a limited trial involving Group B students at an early childhood education institution, which served as the research subject, and by collecting feedback from teachers regarding the developed media. Before conducting the limited trial, the researcher first carried out a preliminary observation to assess the children's level of science literacy prior to using the media. The results of this initial observation showed a percentage score of 47.22%, which falls into the "Beginning to Develop" (MB) category. This indicates that most of the children were still at an early stage of understanding basic science concepts, particularly those related to natural phenomena such as rain. After the pop-up book was implemented in the learning process, a follow-up observation was conducted to assess changes in the children's science literacy achievements. The results showed a significant improvement, with a percentage score of 83.79%, categorized as "Very Well Developed" (BSB). This finding demonstrates that the nature-phenomena-based pop-up book made a positive contribution to enhancing young children's understanding of science in a more contextual, visual, and engaging way. Therefore, this media is not only technically feasible based on expert validation, but also proven to be effective in improving science literacy skills among early childhood learners.

The feedback from teachers regarding the nature phenomenon-based pop-up book aims to ensure that the media is feasible for use by the students. The assessment is based on two main indicators: practicality and usefulness of the media in the learning process. The first assessment yielded a feasibility score of 91.66%, categorized as “feasible.” The second assessment was conducted by the classroom teachers, who gave a score of 100%, also categorized as “feasible.” When these two assessments are combined, the average percentage obtained is 95.83%. These results indicate that both the principal and the teachers consider the nature phenomenon-based pop-up book to be a practical and beneficial media, suitable for use in early childhood education.

The percentage results indicate that the nature phenomenon-based pop-up book is suitable for improving science literacy among children aged 5-6 years at KB Karang Mulya, Cirebon City. When this media was implemented in the learning process, teachers observed that learning activities became more enjoyable and engaging for the students. The nature phenomenon-based pop-up book also facilitated teachers in conveying the learning objectives effectively with supportive visualizations (Dewi, 2021). Furthermore, the principal assessed

that the media is made from safe and child-friendly materials (Rahmat et al., 2016).

The nature phenomenon-based pop-up book is made from high-quality paper with a weight of 230 gsm, ensuring durability and resistance to damage. It is also bound with a hardcover, which enhances the strength and longevity of the media. The use of thick paper and hardcover binding is a significant advantage, making the pop-up book more durable and less prone to tearing. Additionally, the media developed by the researcher features visually appealing illustrations and includes various interactive activities, encouraging children to be more active and engaged during the learning process (Anggraini et al., 2019).(Anggraini et al., 2019).

The pop-up book developed by the researcher introduces a new innovation in its design. The innovation lies in its theme rain phenomena which is first introduced through simple experiments. In addition, the book includes a variety of interactive activities specifically designed for early childhood learners, making it more engaging and enjoyable. By packaging science literacy into playful and enjoyable activities, the learning process becomes more dynamic and meaningful. Centered around natural phenomena, this pop-up book successfully makes science feel accessible and easier to understand for young children (Omaga & Alieto, 2019).

The improvement of science literacy among children aged 5–6 years through a pop-up book based on natural phenomena can be seen from the results of a limited trial conducted by the researcher. Prior to the trial, the researcher carried out an initial observation to assess the children's level of science literacy. The observation results showed an initial percentage of 47.22%, which falls into the "Starting to Develop" (MB) category. After the development and implementation of the pop-up book media, a significant increase was observed. The post-trial results reached 83.79%, placing it in the "Very Well Developed" (BSB) category. These findings indicate that the use of a pop-up book based on natural phenomena is effective in enhancing early childhood science literacy in an enjoyable and meaningful way.

The science literacy level of children aged 5–6 years was obtained through observational assessments conducted before and after the development of a pop-up book based on natural phenomena. This assessment was designed to measure changes in the children's ability to understand scientific concepts in an engaging and contextual manner. The assessment instrument was adapted from six stages of science literacy learning; however, in this study, the researcher selected only four stages that were most relevant and appropriate for early childhood characteristics. This selection was made to ensure that the assessment remained focused, effective, and aligned with the objectives of media development. The results of the assessment provide a

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concrete illustration of the effectiveness of the pop-up book in gradually and meaningfully enhancing children's science literacy.

Table 1. Science Literacy Stages for Children Aged 5–6 Years

No.	Indicator	Observation Statement	Pre-production	Pasca-production
1.	Contact stage	a. The child is able to recognize the rainy season.	22	34
		b. The child is able to understand the process of how rain occurs.	18	30
2.	Curiosity stage	c. The child is able to mention the process of how rain occurs.	15	27
3.	Concept formation stage	d. The child is able to sequence the process of how rain occurs.	15	27
4.	Concept acquisition stage	e. The child is able to write the words (rain, dark clouds, sun, wind, and sea water).	19	36
		f. The child is able to choose rain gear.	18	27
	%		49,53%	83,79%
	Categori		Starting to Develop	Developing Very Well

Based on the table, science literacy in children aged 5-6 years showed a significant improvement after using the learning media. This indicates that the pop-up book media contributes positively to enhancing the quality of children's learning. This media not only captures children's attention but also facilitates the understanding of scientific concepts that are usually abstract and difficult to explain verbally. These findings align with previous studies which emphasize that the use of interactive visual media can strengthen the science literacy learning process, helping children to grasp the material more deeply and enjoyably. Therefore, the utilization of pop-up books becomes an effective strategy to support the development of science literacy in early childhood (Afrih Lia, 2018).

Conclusion

Based on the research results, it can be concluded that the development of pop-up book media based on natural phenomena was carried out through a systematic and structured procedure. The media development design stages followed the procedures of initial information gathering, product design, product validation, product revision, product testing, and final product. The developed media is a pop-up book with the theme of natural phenomena aimed at improving science literacy in early childhood. This well-planned development process helped the researcher produce effective learning media that suits the needs of early childhood learners. Validation results showed a feasibility level of 95.83%, indicating that the pop-up book media based on natural phenomena is highly suitable for use in classroom learning activities. Meanwhile, limited field testing showed an increase in children's science literacy from 49.53% to 83.79%. This demonstrates that the pop-up book media is effective in improving science literacy skills in early childhood. Some advantages include realistic visual images, an interactive, attractive, and enjoyable design for children, facilitation of independent learning, and increased interaction between teachers and children. In the context of early childhood education, the pop-up book media provides benefits in enhancing science literacy skills from an early age, developing simple scientific and logical thinking patterns in children, encouraging creativity, and making it easier for teachers to explain scientific concepts to children. As a suggestion for future research, it is recommended that media development expand content variety by incorporating other themes that are also interesting and relevant to young children, such as the surrounding environment, flora and fauna, or everyday phenomena. Furthermore, future studies could explore the use of interactive digital technology to enrich learning experiences.

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