



Development of a Flashcard Medium Using a Deep Learning-Based 'Shuffle and Recall' Technique to Foster Critical Thinking Skills in Science Lessons

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Abstract: Twenty-first-century learning demands the strengthening of higher-order thinking skills; consequently, innovative teaching materials are required to enhance pupils' critical thinking abilities. This study aims to develop a 'Shuffle and Recall' card-based teaching aid utilising deep learning pedagogical principles (to promote meaningful, high-cognitive engagement) to equip Year 5 primary school pupils with critical thinking skills in science lessons. Based on observations at SDN Kanggraksan, teaching is still dominated by the use of textbooks and workbooks, resulting in students being less active and their critical thinking skills not developing optimally. This study employed the Research and Development (R&D) method using the ADDIE model, comprising the stages of Analysis, Design, Development, Implementation, and Evaluation. The suitability of the teaching aid was assessed through validation by subject matter, media, and language experts, as well as through a student response test involving [insert number, e.g., 32] Year 5 pupils at a state primary school in Cirebon City. Data were collected through observation, interviews, questionnaires, pre- and post-tests, and documentation. Quantitative data were analysed based on the results of the validation, questionnaires, and pre-test and post-test scores, whilst qualitative data were analysed descriptively based on the results of observations, interviews, and expert input. The research findings indicate that the card-based media developed was able to enhance pupils' enthusiasm for learning, critical thinking skills, and understanding of science subject matter. This study suggests that the card-based media can serve as an engaging, interactive alternative for learning that supports the development of pupils' critical thinking skills.

Keywords: Critical thinking; Deep learning; Science learning; Shuffle and Recall media

Introduction

The rapid development of digital technology has brought about significant changes in various aspects of life, including the world of education. The use of technology in education makes the presentation of subject matter engaging, preventing it from becoming monotonous; this keeps pupils interested in learning and maintains their enthusiasm for participating in teaching and learning activities in the classroom (Iswadi & Iriansyah, 2025). Teachers are also required to design

engaging and interactive learning experiences through the use of various smartphone applications, whilst continuing to support the development of 21st-century skills such as critical thinking, creativity, communication, and collaboration (Astria et al., 2025). Rapid and extensive access to information is one of the main advantages of using social media in learning (Kolhar et al., 2021; Beemt et al., 2020). Learners are no longer limited to textbooks or classroom teaching. Platforms such as YouTube, Instagram, Twitter, and TikTok provide a wide variety of content that can help

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learners study various topics independently (Izzatunnisa et al., 2021). Likewise, it has become easier for educators to find references on learning models and teaching methods that make pupils more enthusiastic about learning and enable them to understand the material more easily and enjoyably.

Rapid technological advancements and the demands of the "Merdeka" curriculum—which emphasises the dimension of "Critical Thinking" within the Pancasila Student Profile—guide learning to be student-centered (Suryati et al., 2023). This involves acquiring and processing information and ideas, analysing and evaluating reasoning, reflecting on thoughts and thought processes, and making decisions. Consequently, teachers are no longer the sole source of information, but rather facilitators, mentors, and guides who assist pupils in the processes of exploration, collaboration, and reflection (Ramadani et al., 2025). However, in an observation carried out at one state primary school in Cirebon, teachers were still using conventional methods such as textbooks, student worksheets (LKS), and the lecture method, which is solely teacher-centered. This situation results in pupils being less actively engaged in the learning process and having minimal opportunities to develop critical thinking skills; hence, there is an urgent need to optimise a pupil-centered learning approach, which can be achieved by introducing engaging learning materials that support the development of pupils' critical thinking skills in the classroom.

Innovation in learning, driven by rapid technological development, allows us to find resources such as learning models and engaging, effective teaching methods simply by accessing social media; whatever information we seek is readily available there. The use of technology in learning not only facilitates access to information but also enriches teaching and learning methods (Haleem et al., 2022; Soriano-Sánchez, 2025). When designing learning activities, particularly at the primary school level, these components must be considered comprehensively so that pupils not only follow lessons but also feel engaged, confident, and satisfied with their learning process (Barrett et al., 2015; Zamiri & Esmaeili, 2024). This is because at this stage, pupils are still in the concrete operational stage of development, where they are more responsive to learning that is concrete, visual, and interactive. Learning media play a vital role as tools in learning activities (Charline et al., 2023; Navrátilová & Jurčík, 2025). By utilising such media, teachers can deliver content in a more targeted manner, thereby fostering an effective learning process. Consequently, one form of learning resource that holds strategic potential and is relevant to the demands of the "Merdeka" curriculum—which emphasises critical thinking—is the use of

flashcards in a more engaging and enjoyable game-based format. This is inspired by the "Ruang Guru Clash of Champions" (CoC) programme, an educational game show that tests pupils' critical thinking skills.

One such reference is "Shuffle and Recall", where learning utilises flashcards through a specific technique carried out in groups and comprising three stages (Rahmah et al., 2025; Maharani et al., 2026). In the context of primary school science education, the first stage is "memorise", where pupils match question cards with answer cards accurately—for example, identifying the cause-and-effect relationship behind environmental damage—so that they can understand the science material contained on the flashcards. The second stage is "Recall", in which the teacher collects the index cards back and the pupils review the material on the cards; for example, listing the consequences for living and non-living natural resources if they are damaged. The third stage is "Examine", where the teacher displays a PowerPoint presentation containing the correct answers, and each group takes turns to explain and justify what they reviewed in the second stage. Through this process, this teaching aid encourages discussion and develops pupils' critical thinking in understanding natural phenomena. Learning should not only be enjoyable for pupils but must also be in-depth and meaningful (O'Reilly et al., 2022).

Meaningful and deep learning is aligned with efforts to develop critical thinking skills in learners. Deep learning essentially emphasises activities and the creation of learning conditions that are meaningful, joyful, and mindful (Suherman et al., 2025). This teaching approach is aimed at developing pupils' critical thinking skills, which is in line with the "Merdeka" curriculum that strengthens the development of pupils' critical and creative thinking skills while increasing their engagement in the learning process (Rohman et al., 2026). The deep learning approach requires an active role from teachers in designing learning activities that encourage students to explore, connect concepts, and construct knowledge in a meaningful way. Through this approach, the information received by students is critically analysed, resulting in learning characterised by meaningful and deep understanding where pupils analyse a problem and find solutions based on data and facts.

This approach focuses on creating close links between new knowledge and the pupils' prior experiences and existing knowledge. This process is reinforced through reflective activities and pupils' active participation throughout the entire learning process, with an emphasis on deep understanding and the interconnection of knowledge. At its core, Deep Learning encourages learners to consistently engage in the analysis, evaluation, and reflection of various pieces

of information. These cognitive activities are key characteristics of critical thinking skills and Higher Order Thinking Skills (HOTS). Therefore, the application of the Deep Learning approach in instructional design can serve as an effective catalyst for developing pupils' critical thinking capacities in a more systematic and contextual manner. The novelty of this research lies in the use of Deep Learning-based flashcard media combined with the "Shuffle and Recall" technique in science learning to enhance the critical thinking skills of Year 5 primary school pupils. Previous research by Herawati (2025) only applied the "Shuffle and Recall" technique to Arabic language learning to improve the writing skills of students at the Madrasah Aliyah level. Consequently, this study introduces an innovation through the integration of the Deep Learning framework, the use of flashcard media as an interactive learning tool, its application to the subject of science, and a focus on developing the critical thinking skills of primary school pupils.

Based on the above background, this study examines how flashcard media utilising the Deep Learning-based Shuffle and Recall technique can equip primary school pupils with critical thinking skills. This study will develop flashcard media using the "Shuffle and Recall" technique into a medium that functions not merely as a teaching aid, but as a structured framework that engages pupils actively through the stages of shuffling, recalling, analysing, and reflecting – processes that are directly aligned with critical thinking. Through this study, it is hoped that this research will provide an insight into the effectiveness of utilising technology-based learning media in improving the quality of science education, particularly in developing pupils' critical thinking skills.

Method

This development research utilises the Research and Development (R&D) model, specifically the ADDIE model. This development model takes into account the fundamental details of educational product development, adapting to technology and the needs of learners. The research aims to develop and test a product, as well as assess its effectiveness. The development of this product follows the ADDIE model, which consists of five systematic stages, namely: analysis, design, development, implementation, and evaluation. The Analysis stage aims to analyse learning needs, learner characteristics, the curriculum, and the material to be developed. The Design stage focuses on designing flashcard media, compiling material, and structuring the learning sequence using the Shuffle and Recall technique. Next, in the Development stage, the media are developed in accordance with the design, then

validated by subject matter experts, media experts and language experts, and revised based on suggestions and feedback from the validators. The Implementation stage involves pilot-testing the media with learners using the 'Shuffle and Recall' technique and collecting data through questionnaires, pre-tests and post-tests. The Evaluation stage is a formative evaluation aimed at refining the media based on the results of the validation and pilot testing. The choice of the ADDIE model was based on its structured, comprehensive and easy-to-follow workflow, as illustrated in Figure 1.



Figure 1. Stages of the ADDIE development model (Source: Rayanto & Sugianti, 2020)

This research was conducted at SDN Kanggraksan, with the research subjects being Year 5 pupils in Cirebon City. The object of this research was the flashcard media using the 'shuffle and recall' technique developed for the Natural Sciences subject, specifically focusing on the topic of Living and Non-living Natural Resources. Data collection techniques employed in this study included observation, interviews, questionnaires, pre- and post-tests, and documentation. To support these techniques, the research instruments comprised observation sheets to evaluate actual conditions in the field, interviews to gather in-depth data regarding issues at primary schools, a questionnaire as a tool to assess the suitability of the media, pre- and post-tests to measure changes or improvements in pupils' critical thinking skills, and documentation to corroborate the data.

Qualitative and Quantitative Data Analysis Techniques

Qualitative data was obtained from interviews, observations, and suggestions and input from experts. The qualitative data analysis was carried out in three continuous, non-numbered narrative stages. The first stage is data reduction, which involves selecting, focusing, and simplifying the raw data obtained from the field to ensure only information relevant to the research objectives is retained. The second stage is data presentation, which involves organizing the reduced

data into a narrative form so that it is easy to understand and analyze further. The final stage is drawing conclusions, which entails formulating the final research findings based on the accumulated and analyzed data. Quantitative data were obtained from expert validation, student response questionnaires, and pre-test and post-test scores. The quantitative data analysis was carried out as follows.

Expert Validation Analysis

The average score of the expert validation results was calculated to determine the level of suitability of the developed media. The Likert scale, according to Akbar (2013), was used to structure the response options. The final percentage scores obtained from validators are categorized based on the expert validation criteria shown in Table 1.

Table 1. Criteria for expert validation

Suitability Criteria (%)	Level of Suitability
85-100	Highly valid, or can be used without revision
70-85	Reasonably valid, or can be used but requires minor revision
50-70	Not very valid; it is recommended that it not be used as it requires major revision
01-50	Invalid; must not be used

Pupil Response Analysis

The product's suitability percentage was calculated by comparing the actual score obtained with the maximum possible score. The result was then categorized according to the criteria for the suitability of the student response questionnaires shown in Table 2.

Table 2. Suitability of the questionnaire for pupil responses

Achievement Level (%)	Criteria	Description
81-100	Very Good	Very Good
61-80	Good	Acceptable
41-60	Fair	Fairly acceptable
21-40	Not very good	Not satisfactory

Normalized Gain (N-Gain) Analysis

To evaluate the improvement in pupils' learning outcomes and determine their level of critical thinking ability, pre-test and post-test scores were compared

using the normalized gain (N-Gain) formula. The calculation is structured as follows:

$$N_{\text{Gain}} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}} \quad (1)$$

Table 3. N-Gain criteria

Percentage (%)	Interpretation
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Moderate
$0 < g < 0.30$	Low
$g \leq 0$	Failed

Table 4. Categories for interpreting the effectiveness of N-Gain

Percentage (%)	Interpretation
< 40	Ineffective
40-50	Less effective
56-75	Fairly effective
> 76	Effective

Result and Discussion

The development of a flashcard medium played using the 'shuffle and recall' technique in the teaching of Natural Sciences, specifically the topic of Living and Non-living Natural Resources for Year 5 of Primary School, was carried out using the ADDIE model, comprising the stages of Analyse, Design, Development, Implementation and Evaluation.

Analysis

The first stage in the ADDIE model is analysis, during which the development of a product takes place. The components that must be included in the analysis stage are as follows.

Curriculum Analysis

This analysis was carried out to examine the Learning Outcomes (LO), Learning Objectives (LO), Competency Achievement Indicators (CAI) and the Learning Objective Sequence required by pupils in the process of creating flashcards on the subject of Living and Non-Living Natural Resources. The findings were based on observations carried out at SDN Kanggraksan, which utilises the 'Merdeka' curriculum in its teaching process. The following are the LOs, LOs, CAI and Learning Objective Sequence applied to the flashcard teaching materials.

Table 5. Learning design

Learning Outcomes	Learning Objectives	Competency Achievement Indicators
Pupils are able to analyse the relationship between living organisms and their environment, distinguish	Through the 'Shuffle and Recall' card activity, pupils are expected to be able to analyse the differences between living and non-living natural resources and to conclude the importance of conserving natural resources based on	Classify types of natural resources as living and non-living. Identify problems arising from an observed phenomenon. Explain the impact of

between living and non-living natural resources, evaluate the impact of human activities on environmental sustainability, and devise simple solutions to maintain the balance of nature.	information obtained through the worksheet activity. This learning objective applies the principles of mindful learning and meaningful learning. Pupils are expected to be able to evaluate living and non-living natural resources, along with conservation efforts, by providing accurate explanations of their interrelationships and impacts. This learning objective integrates the principles of meaningful learning and mindful learning. Through the activities in the worksheets, pupils are expected to be able to devise simple solutions and logical strategies to ensure the sustainability of natural resources in line with the learning material. This learning objective applies the principles of joyful learning and meaningful learning.	pollution on living organisms. Extract the meaning or essence from information that has been learnt. Explain the cause-and-effect relationship of environmental damage. Describe the process by which an event occurs in the surrounding environment. Compare two behaviours and provide logical reasons. Explain the interrelationship between one fact and another. Design concrete actions for environmental conservation.
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Table 6. Learning objectives flowchart

Learning competency	Target learning outcome indicators
Analysis and evaluation of natural resources	Pupils are able to analyse the differences between living and non-living natural resources, evaluate conservation efforts, and accurately explain the impacts of pollution, cause-and-effect relationships, the processes by which environmental events occur, comparisons between two behaviours, and the interrelationships between facts, based on observed phenomena.
Problem solving and strategic action	Pupils are able to devise simple solutions to safeguard natural resources, as well as to design strategies and tactics for implementing these solutions logically and in line with the subject matter, in the form of concrete environmental conservation actions.

Analysis of Pupils’ Characteristics

During the character analysis stage, observations and interviews were conducted with Year 5 pupils at SDN Kanggraksan. There are several aspects to assess the pupils’ character, including their social behaviour, knowledge and skills. The pupils’ social behaviour, both in the classroom and within the school environment, is very good; whilst studying, they are able to understand what the teacher explains. However, after studying for a while, some pupils become noisy and start joking around, which can distract their classmates from their studies. When this happens, the teacher immediately reprimands the pupils who are joking, and they immediately fall silent and resume their studies, thus demonstrating mutual respect and a good level of tolerance. Spiritual practices are also observed just before the start of lessons by reciting a prayer first. Year 5 pupils appear active and enthusiastic whilst learning when interactive media are used, as these allow them to engage actively in the learning process. However, when the teacher uses a lecture-style method to explain the lesson, Year 5 pupils easily become bored if the lesson is too long and uses monotonous learning materials such as textbooks; they readily lose focus on their studies. Based on the analysis of the pupils’ characteristics outlined above, a teaching aid is required to address these issues, to help pupils grasp the material more easily and to foster critical thinking. Therefore, the flashcard medium utilising the ‘shuffle and recall’

technique developed by the researcher represents an effort to help pupils understand the subject matter more easily and to enhance their critical thinking skills.

Analysis of Learning Materials

The results of the material analysis, carried out by analysing the learning resources used in teaching and learning activities – namely the Teacher’s Book and the Year 5 Pupil’s Book – revealed that the material used for Natural Sciences lessons on Living and Non-Living Natural Resources aligns with the title of this study, namely the Natural Sciences subject for Year 5 at primary school.

Design

Following the analysis, the researcher proceeds to the second stage, namely the design or product development stage. This stage focuses on two activities: the selection of materials and the design of a product tailored to the needs and issues faced by the learners. There are two sub-stages within the design stage.

Theoretical Design

At this stage, the researcher utilises Norris and Eanis’s theory of critical thinking to design teaching materials that help pupils improve their critical thinking skills, using Norris and Eanis’s theory of critical thinking with indicators including: providing simple explanations; building basic skills; drawing conclusions

(inference); providing further clarification (advanced clarification); e. devising strategies and tactics. This teaching material is designed in accordance with Norris and Eanis’s theory, providing a clear structure to help students understand the subject matter and hone their critical thinking skills. Furthermore, the flashcard material, utilising the ‘shuffle and recall’ technique, incorporates deep learning at every stage, emphasising deeper learning, more complex analysis, and reflective ability in applying knowledge. According to the study by Maruwae et al. (2025), the application of innovative learning in deep learning emphasises three main pillars, namely mindful learning, meaningful learning, and joyful learning.

Selection of Material

The selection of materials was determined at the initial stage of formulating the research title by drawing on the Natural Sciences subject as set out in the Teacher’s Book and Pupil’s Book for Year 5, specifically the material on Living and Non-living Natural Resources. The material covers the differences between living and non-living resources, evaluates conservation efforts, explains the impacts of pollution, cause-and-effect

relationships, and the processes behind environmental events; it also involves creating simple solutions to preserve natural resources, as well as designing logical strategies and tactics for implementing these solutions. Subsequently, in the media products to be developed, the material will be further expanded to broaden pupils’ knowledge, particularly through the inclusion of illustrations and images to help them understand the text and visualise both living and non-living natural resources and their conservation.

Product Design

During the product design stage, the researchers determined the content regarding living and non-living natural resources and their conservation, which would later be included on the flashcards. In the study by Setyawati et al. (2025), the flashcard media was created by designing the content to align with critical thinking indicators, which are incorporated into the flashcards, and structured to meet learning objectives by integrating the ‘Shuffle and Recall’ technique and the Deep Learning approach. There will be 5 question cards and 5 answer cards, and the card pieces will be matched to the corresponding questions and answers.

Table 7. Learning outcomes, objectives, and deep learning

Learning Outcomes	Learning Objectives (Norris Ennis)	Deep Learning
Pupils are expected to be able to analyse the relationship between living organisms and their environment, identify the differences between living and non-living natural resources, evaluate the impact of human activities on environmental sustainability, and devise simple solutions to maintain the balance of nature.	The first learning objective is derived from the Norris-Ennis indicators (building basic skills and drawing conclusions). Through a card game using the ‘Shuffle and Recall’ technique, pupils are able to identify and analyse the differences between living and non-living natural resources based on the information provided, and draw appropriate conclusions regarding the importance of conserving natural resources.	Mindful Learning & Meaningful Learning
	The second learning objective is derived from the Norris Ennis indicators (providing simple explanations and giving further explanations). Through the activity of completing the worksheets, pupils are able to provide simple explanations regarding living and non-living natural resources, as well as give further explanations about the relationships, impacts and conservation efforts regarding natural resources correctly.	Meaningful Learning & Mindful Learning
	The third learning objective is derived from the Norris-Ennis indicators (developing strategies and tactics). Through the worksheet activity, pupils are able to devise strategies and tactics to safeguard natural resources in a logical manner and in line with the learning material.	Meaningful Learning & Joyful Learning

Table 8. Design of questions and answers

Learning objectives	Critical Thinking Indicators (Norris Eanis)	Question indicators	Question	Deep Learning	Card No
Through the Shuffle and Recall card game, students are able to analyze the differences between living and non-living natural resources and draw conclusions about	Build basic skills	types of natural resources based on grouping biological and non-biological	Around the school there are trees, soil, water and air... classify which ones are biological and non-biological natural resources!	Mindful Learning	No. 1
		Identifying problems from an observed phenomenon	Mr Budi Around the school there are trees, soil, water and air... classify which ones are biological and non-biological natural resources!	Mindful Learning	No. 4

the importance of preserving natural resources based on the information provided accurately.

Planting various plants in your yard. However, because plastic waste is often carelessly dumped on the ground, rainwater has difficulty in infiltrating the soil. As a result, the soil becomes hard and less fertile. Plants wilt and fail to thrive.
What is the impact of infertile soil on plant growth?



Figure 2. Storyboard for the card-based media

Development



Figure 3. Flashcard media

The development of the tile-based media was based on an analysis of the problems and needs of the pupils, as well as the design created in the previous stage. In the production of the product, several visual aspects must be taken into account, including text, colours and images appropriate to the subject matter.

Product Validation

Product validation was carried out by presenting the designed or developed product to assess the suitability of the flashcard media design. Product validation was carried out by having media experts, subject matter experts and language experts complete an evaluation questionnaire using a 1–5 rating scale. The validation by media experts, subject matter experts and language experts was carried out by two lecturers in primary school teacher education specialising in science,

and a language expert who is the headteacher of an SDN school in Cirebon.

Table 9. Results of validation by media experts, content experts and language experts

Validator	V1%	V2%	V3%	Result Percentage%	Criteria
Media Expert	80	84	78	81	Reasonably valid, requires minor revision
Subject Matter Expert	92	76	77	82	Reasonably valid, requires minor revision
Linguist	85	84	78	85	Highly valid, no revisions required

Table 10. Product revision results

Before Revision	After Revision
	
Topics that were far removed from the pupils' everyday lives	Topics relevant to the pupils have been added
	
The background in the media was blue	The background in the media uses a lighter shade of blue

Table 9 shows that the validation results from the media experts, subject matter experts and language experts all fall within the 'highly suitable' category, with media experts scoring 81 per cent, subject matter experts 82 per cent and language experts 85 per cent; all validation results were deemed highly suitable and ready for implementation

Product Revision

Product revisions were carried out following the receipt of suggestions and feedback from media experts, subject matter experts and language experts regarding the flashcards, in order to improve the product before it was put into use.



Illustrations that are unclear



The illustrations are now clearer and more realistic



Font size 5



The font size has been increased to 5.7

Implementation

The product trial phase was carried out using a simulation with the flashcards that had been developed,

and the implementation phase utilized the shuffle and recall technique, which consists of three stages, as shown in Table 10.

Table 11. Stages of Shuffle and Recall

Stages of Shuffle and Recall	Implementation
Memories	At this stage, pupils are divided into small groups of four or five, and each group is given a set of index cards comprising two types: question cards and answer cards. The cards are then shuffled, and group members discuss which questions and answers match. Once the correct question and answer cards have been identified, pupils study the material on the matched cards and are given 20 minutes to familiarise themselves with the content. This stage helps pupils become aware of the material on the cards.
Recall	The second stage is the recall stage, in which, after the pupils have understood the content of the cards, the teacher collects the cards that the pupils have already understood in the first stage. The teacher then distributes worksheets to the pupils that are still related to the content of the cards, which they will later review and rewrite on their worksheets. At this stage, 15 minutes are allocated, making the learning more meaningful as the material is still relevant to the pupils' immediate environment.

Examine	The third stage is the 'examine' stage, in which the teacher displays the correct answers via a PowerPoint presentation, which are then corrected collectively. A group representative reads out their group's results to check whether the answers are correct or not; if there are any shortcomings, these can be corrected together. This stage helps to make learning enjoyable for the pupils.
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The pilot test stage in this study consisted of a single phase, namely a large-group pilot test, which was conducted with 18 Year 5 pupils. At this stage, the researcher carried out the pilot test in accordance with the lesson plan (RPP) that had been designed and in line with the Natural Sciences subject, covering the topic of Living and Non-living Natural Resources. The results of the large-group pilot test are shown below.

Table 12. Results of the large-group pilot test

Pilot Study	Result Percentage (%)	Category
Large Group	84.58	Highly Recommended

Evaluation

Evaluation is the final stage in the ADDIE development model. In this study, only formative evaluation was carried out; that is, evaluation conducted to collect data at each stage, which was used to refine the teaching aid. The following are the final results of the flashcard teaching aid on living and non-living natural resources.

Table 13. N-Gain results

	Descriptive Statistics			
	N	Min	Max	Mean
N-Gain	15	.29	.100	.6753
Valid N Listwise	15			



Figure 4. Final product flashcard teaching aids

Based on the results of the large-group product trial, a score of 84.58 per cent was obtained; in line with this percentage, it can be concluded that the card-based medium using the 'shuffle and recall' technique is highly suitable for use. At this stage of the research, only descriptive statistical tests were carried out to determine

the N-Gain; tests of effectiveness will be continued in future research. Based on the results of the N-Gain analysis, an average value of 0.67 was obtained, which, when expressed as a percentage, is 67.53 per cent, falling within the 'moderately effective' category. This indicates that the use of flashcards with the 'shuffle and recall' technique is able to improve students' critical thinking skills quite effectively.

Discussion

The results of the flashcard development indicate that the resource has successfully met the three main criteria: development, feasibility and practicality; it is therefore hoped that this resource can serve as an effective solution to improve the quality of learning in Year 5 at SDN Kanggraksan. The development of the flashcard teaching material utilised the ADDIE model, which comprises five stages: analysis, design, development, implementation and evaluation. The ADDIE model was selected due to its structured and detailed approach, ensuring that each stage of development could be carried out systematically and effectively (Shakeel et al., 2023). During the initial analysis stage, the researchers identified learning problems in Year 5 at SDN Kanggraksan through observation and interviews with teachers. Based on the findings, it was noted that in science lessons covering living and non-living natural resources, teachers were still using the lecture method, supported by teacher and pupil textbooks. This approach proved to be ineffective in boosting pupils' interest and enthusiasm. Pupils often displayed signs of boredom, were unengaged, and did not participate actively in the learning process, due to the monotonous delivery of the material and a lack of varied learning resources. The results study by Beigzadeh et al. (2024), the monotonous lecture method is characterised by a repetitive, unvarying learning process that positions the teacher as the sole source of information, thereby making the learning process highly teacher-centred. Based on this analysis, the researchers subsequently designed the development of a card-based learning resource to address this issue and improve the quality of learning.

In the second stage of the design process, the researcher began to develop the main framework for the flashcard-based teaching material to be created. This stage involved selecting the teaching material based on the results of the analysis of learners' needs, determining the content in accordance with the Norris-Ennis indicators – which enable pupils to think more critically

whilst learning—as well as designing the flashcards visually and creating an engaging narrative. Through the use of illustrated images, pupils are able to connect the topics under discussion via realistic depictions that are far clearer, so that ideas that were previously complex ultimately feel much simpler (Darling-Hammond et al., 2020; Strouse et al., 2018). During this design process, the researcher also formulated material that is easily understood through the media and enables pupils to think critically; the illustrations created appear more realistic, and the cards are arranged with an attractive design appropriate to the material, so as to align with the learning objectives to be achieved in accordance with the characteristics of Year 5 pupils at SDN Kanggraksan. During the development stage, the researchers first had the product validated by media experts, subject matter experts and language experts before it was implemented. Several suggestions and inputs were received from the validators; amongst them, the subject matter expert suggested addressing issues that were relevant to the pupils' lives. In line with the research on Abdullah (2024) learning that utilises the surrounding environment as a resource can provide direct and real-life experiences for pupils.

A suggestion from a media expert is to change the background of the flashcards to a lighter shade; the background, which was previously a dark blue, has been changed to a lighter blue. This is in line with Xu et al. (2022) and Petrová et al. (2026); the use of colour contrast can help to highlight important elements in an illustration, thereby helping to direct children's attention to the details emphasised in the story. It is recommended to include illustrations that are more realistic and relevant to everyday life. Visual aids are used for material that cannot be explained through text alone and cannot be observed directly in the field (Pantaleo, 2025; Kooijmans et al., 2024). As well as helping to clarify the material, visual media also play a role in fostering pupils' interest, motivation and enthusiasm for learning. Media experts suggest that the font size on the cards be slightly enlarged so that pupils can read the text more clearly; this is in line with the research. Comprehension of a text is largely determined by the reader's active engagement in the process of gaining that understanding. This means that the process of comprehension does not occur automatically, but rather requires a thinking process that takes place through the activity of connecting relevant prior knowledge.

Once the validation stage is complete, the teaching material is revised in accordance with the suggestions and feedback from the validators; only after these improvements have been made will the new teaching material be implemented. During the development stage, the material will be formulated into questions and

answers contained within flashcard media, which will focus on students' ability to distinguish between living and non-living natural resources, the causes and effects of natural events, and strategies and tactics to prevent natural events. Following the development of the content, the researcher created visual illustrations using graphic design software, such as Canva, to produce the flashcard materials, utilising ChatGPT Premium to generate engaging images to support the content. The researcher ensured that every visual element was closely linked to the content so that learners would not only be visually engaged but would also find it easier to understand the material presented on the cards.

Once the product had been fully developed, the flashcard media was then tested through expert validation to ensure its suitability. The validation was carried out by three experts—a media specialist, a subject matter expert and a language specialist—to assess the visual quality, clarity of language and alignment of the content with the curriculum. Based on the validation results, the media aspect received a score of 81 per cent, indicating that these flashcards have an attractive visual presentation, the illustrations used are appropriate to the content, and they present information clearly and effectively. Furthermore, the content aspect received a score of 82 per cent, indicating that the content is in line with the curriculum and the learning topics for Living and Non-Living Natural Resources. These results indicate that the flashcard medium is highly suitable for use as a learning medium in Year 5 at SDN Kanggraksan. This finding is consistent with research conducted by Yuliasari & Amini (2026), which states that there is an improvement in the learning achievements of pupils taught using illustrated flashcards on the topic of the solar system. Following validation, this medium was applied during the implementation phase to test its practicality in learning activities.

The implementation phase was carried out through a large-group trial to determine the effectiveness of the illustrated card media in enhancing students' critical thinking skills. The large-group trial involved 18 pupils. The results showed a highly satisfactory percentage of 84.58 per cent. This percentage indicates that the illustrated card media is easy to use and capable of enhancing pupils' critical thinking skills. Visual media facilitates the creation of an enjoyable and interactive learning atmosphere, where pupils not only receive written information but also gain knowledge through more engaging visuals, thereby creating a positive effect on improving their understanding of the subject matter in learning (Fitriyani & Sari, 2024; Staneviciene & Žekienė, 2025). When implemented in Year 5 at SDN Kanggraksan, these flashcards successfully brought about a significant change in the learning atmosphere. Previously, pupils appeared to get bored easily and

lacked enthusiasm when lessons were delivered using the lecture method. However, after using the flashcards, the classroom atmosphere became more active and communicative. Pupils were more engaged in lessons using the deep learning approach with flashcards, employing the 'shuffle and recall' technique, which comprises three stages.

In Table 7, during the first stage—memorise'—pupils were able to group the question cards and answer cards correctly; during this stage, pupils were able to discuss and collaborate effectively with their peers and were able to think more critically in order to match the correct questions with the correct answers. According to Ramdani et al. (2022), the collaborative learning process enables students to develop critical thinking skills by giving them the opportunity to debate new ideas and reflect on what they have previously said. In the second stage—the 'recall' stage—students have already understood the content of the cards. In the first stage, 'memorise', pupils are able to recall and revisit the material on the cards, which enhances their ability to understand the material more deeply by reviewing what they have already learned, in line with Biwer et al. (2020). Memory is a crucial element in pupils' cognitive processes. This is because memory is directly linked to the storage of information. Memory is one of the factors contributing to a student's learning success. In the second stage, students are able to review the material they have learnt in the first stage. The third stage is the 'examine' stage, where each group competes to provide the correct answer; this ensures that students do not find learning difficult and find the process more enjoyable. In line with the Sun et al. (2022) and Lazzara et al. (2025), interaction in play-based learning is a dynamic process in which pupils are actively engaged in activities that combine elements of play with learning. This is evident from the increased student participation in class discussions, as well as positive changes in student behaviour, enabling them to think more critically to understand the material and find solutions to natural phenomena depicted on the cards.

These findings are consistent with the fact that educational cards are designed to facilitate the learning process for students. In practice, pupils are divided into several groups and then encouraged to play a card game to answer the questions on the educational cards. This approach not only makes learning more engaging for pupils but also contributes to improving their learning outcomes. This demonstrates that the use of visual-based learning materials can create a more engaging and effective learning environment. Learning using flashcards and the 'shuffle and recall' technique, whereby, in the first stage, pupils are able to think more deeply to determine appropriate questions and answers and gain a deeper understanding of the material; this

approach encourages pupils to comprehend the information, rather than merely memorising it, according to Sudarmono et al. (2025). Through the application of deep learning, pupils are expected not only to memorise information but also to understand it deeply, make connections between concepts, and apply their knowledge in real life. Pupils are also able to review the material on the cards and are encouraged to think critically to arrive at the correct answers. In line with Simonovic et al. (2023), critical thinking refers to the ability to reflect on, re-examine, and modify existing thoughts.

Pupils are able to explain the material they have learnt to their classmates; at this stage, they are trained to have confidence in their answers, which reflects an individual's belief in their own ability to face challenges, complete tasks and make decisions independently. By explaining the material to their peers, pupils demonstrate that the quality of peer relationships has a significant impact on their level of self-confidence and social adjustment skills (Li et al., 2026). The evaluation stage involved analysing the results of expert validation, product revisions, learner feedback, and the outcomes of the media's implementation during the learning process. Based on these evaluation results, the flashcard media utilising the Deep Learning-based 'Shuffle and Recall' technique was deemed to meet the feasibility criteria following refinements in line with feedback from validators, covering aspects of content, presentation and language. Consequently, the developed teaching aid is aligned with the learning objectives and the characteristics of the learners. The evaluation results also indicate that the flashcard teaching aid received a very positive response from the learners and was effective in fostering critical thinking skills, as evidenced by the pre-test and post-test results and the N-Gain analysis.

The application of the 'Shuffle and Recall' technique, combined with a deep learning approach, encourages pupils to engage actively in the learning process through activities such as recalling, matching information, discussing and drawing conclusions. Therefore, the flashcard medium developed is considered suitable for use as an alternative science learning resource to support the development of pupils' critical thinking skills in primary schools. The flashcard medium offers long-term benefits in enhancing pupils' learning and developing their critical thinking skills. Through the presentation of stories accompanied by visual illustrations, pupils become more motivated to read and explore the content of the stories, thereby improving their understanding of the subject matter. In conclusion, the results of the development of this flashcard medium show that it is not only suitable and practical for use but also effective in enhancing pupils' critical thinking skills in the subject of Living and Non-

Living Natural Resources. Through the development of the flashcard medium, teachers can create a more interactive, engaging and meaningful learning environment for pupils.

Conclusion

Based on the research findings, it can be concluded that the flashcard medium using the 'Shuffle and Recall' technique based on Deep Learning, developed for the subject matter of living and non-living natural resources, is deemed suitable for use in Year 5 primary school science lessons. The suitability of the medium is supported by expert validation results, teacher feedback, and pupil responses, which collectively indicate that the medium meets the criteria for a viable learning tool. Furthermore, the implementation of this teaching aid demonstrates the potential to improve pupils' critical thinking skills through guided activities such as identifying, analyzing, providing explanations, drawing conclusions, and devising problem-solving strategies. The integration of the 'Shuffle and Recall' technique with the Deep Learning approach shows positive indications of creating a more active, meaningful, and enjoyable learning experience, thereby fostering enthusiasm and helping pupils comprehend the material more easily. Given these descriptive outcomes, this study suggests that flashcards can serve as a promising alternative learning medium to support the development of pupils' critical thinking skills. Because the initial effectiveness of this medium was measured within a descriptive framework, future research is highly recommended to conduct rigorous effectiveness testing using control classes and inferential hypothesis testing. Expanding this medium to other science topics and subjects will further establish its empirical impact on learner-centered education.

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Author Contributions

Conceptualization, methodology, validation, formal analysis, investigation, A.N.A.F.; resources, data curation, writing—original draft preparation, N.T.; writing—review and editing, visualization, D.P.P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The author declares no conflict of interest.

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