



Journal of Educational Sciences

Journal homepage: <https://jes.ejournal.unri.ac.id/index.php/JES>



P-ISSN
2581-1657

E-ISSN
2581-2203

Development of a STEM-Based Board Game "Nest" on the Harmony in Ecosystems Subject to Support Fifth Grade Elementary School Students' Learning Motivation

Nabilla Cahya Khairunisa^{*1}, Erna Suhartini¹, Ramla²

¹ Faculty of Teacher Training and Education, Mulawarman University, Samarinda, 75123, Indonesia

² Public Elementary School 008 Samarinda Ilir, Samarinda, 75116, Indonesia

ARTICLE INFO

Article history:

Received: 01 Oct 2026

Accepted: 08 Oct 2026

Available Online: 15 Oct 2026

Keywords:

Boardgame,
Ecosystem,
Learning Motivation,
STEM

* Corresponding author:

E-mail: khaainsa20@gmail.com

Article Doi:

<https://doi.org/10.31258/jes.10.10.p.673-692>

This is an open access article under the [CC BY-SA](#) license.



ABSTRACT

Student learning motivation in Natural and Social Sciences (IPAS) in elementary schools remains low because of teacher-centered learning and limited media. This study aimed to develop Nest Boardgame, a physical STEM (Science, Technology, Engineering, and Mathematics) board game on Harmony in Ecosystems, and to test its feasibility for supporting learning motivation. This research and development (R&D) study used the ADDIE model with 31 fifth-grade students. Instruments included needs questionnaires, expert validation sheets, teacher and student response questionnaires, STEM-based Student Worksheets (LKPD), and ARCS (Attention, Relevance, Confidence, Satisfaction) motivation questionnaires. Nest Boardgame was rated very valid by language experts (92.5%), material experts (96.2%), and media experts (91.9%). In the small- and large-scale trials, student responses were 90.63% and 90.16%, teacher responses 80.56% and 86.11%, and worksheet achievement 84.37% and 78.85%. In the large-scale trial, effectiveness was measured by changes in ARCS motivation scores after a short simulation and a full game increased significantly (Wilcoxon, $p < 0.001$; normalized gain (N-Gain) of 0.36, moderate). The novelty lies in the integrating STEM into the game mechanism, each round requires a specific STEM domain while simulating the food chain, energy transfer, and natural events. This medium is valid, practical, and quite effective.

1. Introduction

Twenty-first-century learning requires students to possess critical reasoning, the ability to connect scientific theory to real-world contexts, mastery of information and communication technology (ICT), and teamwork skills. Achieving these competencies requires a comprehensive learning methodology that supports both knowledge acquisition and skill development (Sapitri et al., 2022). In practice,

however, IPAS instruction in schools often still relies on lectures and rote memorization, which does not optimally foster students' critical thinking and problem-solving (Indrawati et al., 2025). This gap calls for a shift toward learning models that respond better to the needs of the modern era. *The Science, Technology, Engineering, and Mathematics* (STEM) approach integrates four disciplines to train students to think logically, creatively, and practically when solving real-world problems (Supriyatna et al., 2025). It is considered highly contextual because it has been shown to improve students' readiness to face the complexity of 21st-century challenges (Patras et al., 2024). One topic in Grade V, Phase C IPAS that suits the STEM approach well is Harmony in Ecosystems, which discusses the reciprocal relationship between living things and their habitats. A deep understanding of this topic is expected to foster students' concern and commitment to environmental balance (Rosmawati et al., 2024). Therefore, STEM does not merely address the limitations of traditional science teaching but also provides a foundation for preparing a generation that is responsive to the dynamics of the 21st century.

Although STEM is conceptually relevant, its application to the Harmony in Ecosystems topic still faces obstacles, not only in understanding the material but also in students' low learning motivation (Rahmawati & Adanti, 2023). Observations and interviews at SD Negeri 008 Samarinda Ilir showed that instruction was still monotonous and teacher-centered, so students tended to be less enthusiastic and had difficulty understanding ecosystem material. This is in line with previous research showing that prolonged monotonous lectures cause learning fatigue, declining interest, and negative emotions such as boredom and tiredness, leaving students without a strong drive to learn and unable to achieve optimal outcomes (Mutia et al., 2025). The media used were limited to textbooks, YouTube videos, posters, and simple teaching aids, and 71.88% of students needed more innovative learning media.

This condition confirms that the scarcity of teaching aids, in both availability and creativity of presentation, is a dominant factor suppressing students' learning motivation (UA Sari et al., 2025). Increasing learning motivation can be linked to the four components of the ARCS model (*Attention, Relevance, Confidence, Satisfaction*) proposed by Keller, as cited in Darmansyah (2023), namely focused attention, relevant material, self-confidence, and learning satisfaction. These components require teaching media that are engaging, interactive, and appropriate to students' psychological characteristics. Elementary school students are generally still in the concrete operational stage of Piaget's cognitive theory, in which scientific phenomena are more easily grasped through concrete objects, hands-on experience, and games (Susanto et al., 2024). Therefore, concrete media that are fun and participatory are essential for ecosystem learning in elementary schools. Physical *board games* meet this need because the boards, cards, and tokens involve touch and movement, not just sight and hearing (Wibawanto, 2024). In digital *games*, components are displayed on a screen, whereas in the *Nest Boardgame*, students place organisms, manage energy tokens, and play cards directly, allowing them to experience STEM concepts through hands-on activities. Furthermore, teacher interviews indicated that internet access hinders consistent use of digital media, whereas *board games* are not dependent on technological devices. The need for

concrete media also aligns with the Merdeka Curriculum, which encourages teachers and prospective teachers to understand the curriculum's direction and to develop adaptive instructional media (Yanuar & Sari, 2025; Zahra et al., 2025).

Previous studies have shown that modern learning media such as animations, interactive slides, and digital educational games can increase student motivation more effectively than conventional lectures (Maharani et al., 2024). However, these studies have focused mainly on software or digital tools and have rarely addressed physical teaching media integrated with a STEM framework. For example, Suhartini and Haerani (2022) tested a STEM-oriented e-module on the East Kalimantan tropical rainforest ecosystem, but it was a digital product without an interactive physical game. Meanwhile, Rusnah et al. (2024) used a communicative ecosystem *board game* for elementary students but did not incorporate the STEM approach into its components. Thus, the research gap lies in the lack of no ecosystem learning media in the form of physical games have been found that integrate the four STEM elements into the game mechanics and whose impact on motivation is examined in each aspect of ARCS. This literature gap underlies the urgency of developing teaching media that combine the strengths of interactive physical board games with an integrated STEM framework to maximize student motivation on ecosystem material at the elementary level.

Based on this gap, *Nest Boardgame* was developed as a STEM-based learning medium for the Harmony in Ecosystems topic in elementary schools. The term “*Nest*” refers to a nest or shelter for living things, representing the interconnectedness of ecosystem components. A *board game* is not merely a learning aid but a tool that can facilitate analytical and collaborative learning experiences and increase students' motivation and active involvement (Nilasari et al., 2026). *Nest Boardgame* integrates all four STEM elements into its game mechanics. Science is reflected in understanding ecosystem concepts and relationships among living things; *Technology* is realized through the systematic design of interactive learning media; *Engineering* is integrated through developing game strategies based on habitat conditions, energy, and ecosystem dynamics; and *Mathematics* is applied in scoring, energy management, and decision-making based on points earned during play. The novelty of this research lies in the integration of STEM as a requirement in the game flow, rather than as additional material or visual complements, so that students apply STEM concepts during play. Therefore, *Nest Boardgame* offers a more interactive learning experience through a physical game that integrates ecosystem concepts contextually, so students can directly understand the relationships among ecosystem components through an enjoyable play experience.

This study used a research and development (R&D) method with the ADDIE model, which comprises the *analysis, design, development, implementation, and evaluation stages*. The results are expected to increase student learning motivation, provide an innovative alternative learning medium for teachers and schools, and enrich research on STEM-based learning media at the elementary level. Based on this description, this study aims to (1) develop a STEM-based *Nest Board Game* on the topic of “Harmony in Ecosystems” for fifth-grade elementary school students;

(2) to test its validity based on expert evaluation and its practicality based on teacher and student feedback as well as student achievement on the worksheets; and (3) to analyze improvements in students' learning motivation in terms of *attention, relevance, confidence, and satisfaction* (ARCS).

2. Methodology

This study applied the *Research and Development* (R&D) approach and adopted the ADDIE model, which consists of five systematic stages: *analysis, design, development, implementation, and evaluation* (Mawarni & Hendriyani, 2021). The model was selected because it covers all design phases comprehensively, from needs mapping to final assessment, ensuring that product development is structured, measurable, and planned (Nugroho et al., 2024). Data were collected at SD Negeri 008 Samarinda Ilir, East Kalimantan, in the 2025/2026 academic year. The subjects were 3 material validators, 2 language validators, 3 media validators, 1 fifth-grade teacher, and 31 fifth-grade students. The effectiveness of the media was measured using a *one-group pretest-posttest design*, which was also used in a study of *pop-up book media* for fifth-grade IPAS learning (Permatasari et al., 2026).

Instruments

Data were collected using five groups of structured instruments aligned with the ADDIE flow: (1) needs questionnaires for teachers and students and a teacher interview guide in the *analysis stage*; (2) validation sheets for media design, material content, and language experts in the *development stage*; (3) a student learning motivation questionnaire developed from the four dimensions of the ARCS framework (*Attention, Relevance, Confidence, Satisfaction*); (4) teacher and student response questionnaires in the *implementation stage*; and (5) STEM-oriented Student Worksheets (LKPD) in the *evaluation stage*. The distribution of dimensions and the number of items for each instrument are summarized in Table 1.

Table 1. Summary of Research Instruments

Instrument	Usage Stage	Number of Aspects	Number of Items
Teacher Needs Analysis Questionnaire	<i>Analysis</i>	7	16
Student Needs Analysis Questionnaire	<i>Analysis</i>	5	17
Teacher Interview Guidelines	<i>Analysis</i>	6	20
Expert Validation Sheet (Media, Material, Language)	<i>Development</i>	3	29 (14,7,8)
Learning Motivation	<i>Implementation</i>	4	24

Questionnaire (ARCS)			
Teacher Response Questionnaire	<i>Implementation</i>	7	18
Student Response Questionnaire	<i>Implementation</i>	4	8
STEM-Based Student Worksheets	<i>Evaluation</i>	4	12

The teacher needs questionnaire combined a checklist, short-answer items, open-ended questions, and an attitude scale. The student needs questionnaire used a four-point Likert scale combined with several *checklist items*, while the teacher interview guide contained open-ended questions to gather more comprehensive information. The expert validation sheets (material, media, and language) used a five-point Likert scale (5 = Very Good, 4 = Good, 3 = Fair, 2 = Poor, 1 = Very Poor) (Effendi et al., 2021). In contrast, the teacher and student response questionnaires and the ARCS motivation questionnaire used a four-point Likert scale (4 = Strongly Agree, 3 = Agree, 2 = Disagree, 1 = Strongly Disagree) (Erinsyah et al., 2024). The ARCS motivation questionnaire consisted of 24 statements, 6 for each ARCS dimension, with items 5, 11, 17, and 22 written as negative statements (*reversed items*). The STEM-based LKPD comprised 12 essay questions representing the four STEM domains to evaluate students' active engagement. The researcher scored the answers with a 0–2 rubric: a score of 2 for correct, complete answers consistent with scientific concepts or the play experience; 1 for partially correct or incomplete answers; and 0 for incorrect, irrelevant, or blank answers. Thus, the maximum LKPD score was 24 points. Assessment of written answers on STEM-based worksheets using a graded analytical rubric was also carried out in other studies, although with a scoring scale of 1–3 (Flamonia et al., 2026). The LKPD grid is presented in Table 2.

Table 2. STEM-Based LKPD Grid

No	STEM aspects	Indicator	Item Number	Number of Items
1	<i>Science</i>	Identifying biotic and abiotic components; constructing food chains; analyzing the impact of natural events (<i>event cards</i>) on organisms; explaining the transfer of energy between trophic levels	1-4	4
2	<i>Technology</i>	Identify the function of the card system as a game controller; apply the results of reading system instructions to determine the next step.	5-6	2
3	<i>Engineering</i>	Designing organism placement strategies; correcting strategies when card disruptions occur; evaluating differences in early and late game strategies.	7-9	3

4	Mathematics	Calculate and manage energy/points; calculate the final total score; compare and analyze scores between players	10-12	3
---	-------------	---	-------	---

Data Collection

In the *analysis stage*, data were collected through observations, teacher interviews, and questionnaires for teachers and students to identify learning conditions, problems, and the need for learning media on the Harmony in Ecosystems topic (Aliifah et al., 2023; WN Sari & Fajrie, 2023). The *design stage* included designing *Nest Boardgame*, namely drafting the game rules, component storyboards (boards, cards, pawns, tokens, and guidebooks), and integrating the STEM approach into the game mechanics. In the *development stage*, the product was built according to the design and then validated by eight validators (three media experts, three material experts, and two language experts) to assess its appearance, content, and language. The validation results served as the basis for revisions before the trials. The *implementation stage* consisted of two trials with 31 fifth-grade students. The small-scale trial involved four students as players to obtain initial practicality data through student and teacher response questionnaires and to identify technical problems for revision. The game was guided by another student as a referee, who only supervised the game and did not complete the LKPD, motivation questionnaire, or response questionnaire.

The large-scale trial involved the remaining 27 students, including the student who had served as the referee in the small-scale trial. They were divided into seven groups of four students, and one group lacking a member was completed by a student who had already played in another group. The four students from the small-scale trial no longer played but served as referees who guided the game. In both trials, the learning motivation questionnaire was administered twice. *The pre-test* was administered after a brief simulation of 1-2 rounds of play because the questionnaire items inquired about experience with *Nest Boardgame*, and most students had no prior exposure to boardgames and could not be meaningfully answered without prior exposure. Consequently, *pre-test scores* tended to be higher than those in the no-exposure condition, narrowing the room for improvement and reflecting the shift from initial impressions to full play experience; this is discussed in the limitations section. *The post-test* was administered after students finished the game and completed the LKPD and the student response questionnaire. One fifth-grade teacher completed the teacher response questionnaire in both trials. In the *evaluation stage*, formative evaluation was conducted at every development stage to improve the product continuously, including after the small-scale trial as the basis for revision before the large-scale trial. Summative evaluation was conducted at the end of the study to assess the overall feasibility and effectiveness of the product, including through the STEM-based LKPD that students completed after playing *Nest Boardgame* in both trials.

Data Analysis

Qualitative data from teacher interviews and open-ended questions in the teacher questionnaire were analyzed through three stages, namely data reduction (sorting and grouping answers based on similarity of meaning), data presentation in the form of categories or themes, and drawing conclusions, which were then used to complement and explain the quantitative results. The needs analysis questionnaire data were analyzed descriptively as the percentage frequency of responses, while the other data were analyzed using quantitative descriptive analysis to assess media feasibility, practicality, and student learning motivation with the following percentage formula:

$$P = \frac{\sum X}{\sum X_{maks}} \times 100\% \dots (1)$$

where P is the feasibility percentage, $\sum X$ is the total score obtained, and $\sum X_{maks}$ is the maximum possible score according to each instrument's scale (1–5 for the validation sheets, 1–4 for the response and motivation questionnaires, and 0–2 per item for the LKPD). Using the same formula for all instruments keeps results from different data sources comparable within a 0–100% range. The percentages from the expert validation sheets were then interpreted using the categories in Table 3 (Fadhillah & Octarya, 2023; Nofriza & Zen, 2024; Widyaningrum et al., 2025) .

Table 3. Category Interpretation Percentage

Percentage (%)	Validity	Practicality	Motivation to learn	STEM Engagement
81-100	Very Valid	Very Practical	Very High	Very Good
61-80	Valid	Practical	High	Good
41-60	Fairly Valid	Fairly Practical	Moderate	Fairly Good
21-40	Invalid	Less Practical	Low	Not Good
0-20	Very Invalid	Impractical	Very Low	Very Poor

Nest Boardgame was considered feasible for trial if the validation results from all three experts (media, material, and language) were at least in the “Valid” category; results in the “Fairly Valid” category or below required revision before the *implementation stage*. The media were considered practical if teacher and student responses were at least 61% (the “Practical” category) and able to facilitate students' STEM engagement if the LKPD score was at least in the “Good” category. *Pre-test* and *post-test* motivation scores were categorized according to Table 3. The mean score and the improvement in learning motivation (*normalized gain*, N-Gain) were calculated using the following formulas:

$$\bar{X} = \frac{\sum X}{N} \dots (2)$$

$$g = \frac{\text{Skor Post} - \text{Skor Pre}}{\text{Skor Maks} - \text{Skor Pre}} \dots (3)$$

where $\bar{X}$ is the mean score, $\sum X$ is the total score obtained, N is the number of respondents, and g is the N-Gain value. N-Gain was classified into three categories: high ($g > 0.7$), moderate ($0.3 \leq g \leq 0.7$), and low ($g < 0.3$) (Condong et al., 2026). High or moderate N-Gain indicates that the media were effective in increasing learning motivation, whereas low N-Gain indicates that the improvement was not yet optimal and that the media needed further refinement. Differences between *pre-test* and *post-test* motivation scores were tested at a significance level of $\alpha = 0.05$ using SPSS. In the small-scale trial ($n = 4$), the scores were analyzed with the non-parametric Wilcoxon Signed Ranks Test because the very small sample made it difficult to meet the normality assumption. In the large-scale trial ($n = 27$), the normality of the differences between *pre-test* and *post-test* scores was first tested with the *Shapiro–Wilk test*. If the data were normally distributed, a *paired-samples t-test* was used; otherwise, the *Wilcoxon Signed Ranks Test* was used. The difference was considered statistically significant when *Asymp. Sig.* < 0.05 . The same procedure was applied to each ARCS dimension in the large-scale trial. N-Gain was not calculated for students who had already obtained the maximum *pre-test score* because no room for improvement could be computed.

3. Results and Discussion

Nest Boardgame was implemented with fifth-grade students at SD Negeri 008 Samarinda Ilir through two trials involving 31 students: a small-scale trial with 4 players and 1 referee, and a large-scale trial with 27 students divided into 7 groups of 4 and guided by 4 referees from the small-scale trial. In each trial, students first took part in a short 1–2-round simulation and completed the ARCS motivation questionnaire as a pre-test, then played the game to completion, and finally completed the STEM-based LKPD, the student response questionnaire, and the ARCS motivation questionnaire as a post-test. The fifth-grade teacher completed the teacher response questionnaire in both trials. Before this implementation stage, the product went through needs analysis, design, and expert validation, as described below.

Needs analysis promotes data-based learning planning grounded in real needs rather than merely following the curriculum's administrative steps (Yulianto, 2026). The results showed that IPAS instruction on Harmony in Ecosystems in Grade V was still conventional: teachers relied on textbooks and occasionally on learning videos, while other visual media such as illustrations and PowerPoint presentations were rarely used. This worsens comprehension problems because the material is delivered with little visualization and interactivity (Rahmani et al., 2025). Students still had difficulty distinguishing food chains from food webs, understanding the reciprocal relationships among plants, animals, and humans, and grasping the abstract process of photosynthesis, given that children aged 7–11 are still in the concrete operational stage and need concrete visual media to understand abstract concepts (Purwanti & Fanani, 2024). This difficulty is natural because the interactions between organisms and the transfer of energy in the food chain cannot always be observed directly by students (Pinkan & Yatri, 2026). In contrast, students showed a strong tendency toward active learning: 34.5% preferred learning

through play or hands-on practice and 36.4% through pictures or videos, compared with only 29.1% who preferred listening to the teacher's explanation.

Most students had never encountered board games but showed high interest once the concept was introduced, in line with findings that systematically designed board games increase elementary students' interest and motivation to learn (Aisah et al., 2024) . Teacher interviews reinforced this finding: student enthusiasm depended strongly on the availability of learning media, while the media available at school (projectors, videos, teaching aids) were limited in number and variety, and unreliable internet access hindered consistent use of digital media. The teacher considered *board games* a suitable alternative because they do not depend on technological devices and encourage direct student engagement. These findings became the empirical basis for developing the STEM-based *Nest Boardgame* as an alternative medium for the Harmony in Ecosystems topic.

Based on the needs analysis, the researchers designed *Nest Boardgame* as a STEM-based learning medium for the Harmony in Ecosystems topic. The design began with drafting the game concept and component storyboards: the main board (ecosystem map), player board (organism area), organism tokens, energy tokens, score tokens, zone bonus tokens, action cards, and event cards. All components were accompanied by a main guidebook and a player guidebook as references for running the game. The main board serves as an Ecosystem Map divided into three zones with different energy sources and score bonuses: a high-light zone (sunlight energy, suitable for producer organisms), a water zone (water energy), and a forest zone (nutrient energy, where living things interact). The player board serves as the Organism Area, where each player keeps their organism, energy, and score tokens and action cards; players can take the role of plants (producers), herbivores, carnivores, or decomposers according to the ecosystem's food chain. Figure 1 shows the main board and the player board. Organism tokens represent these four roles at tiered levels, with scores increasing as levels rise; each player receives 12 organism tokens. Energy tokens (light, water, nutrients) function as resources and currency, score tokens record points, and zone bonus tokens are awarded to organisms that survive until the end of the game according to their zones. Figure 2 shows the three types of tokens.



Figure 1. Main Board and Player Board

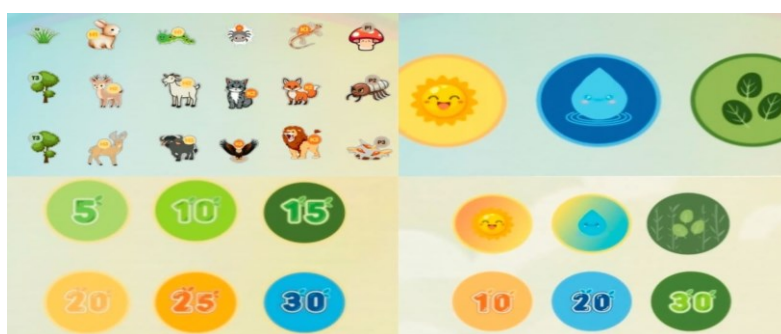


Figure 2. Organism Tokens, Energy, Score, and Zone Bonus

Action cards represent interactions among organisms, such as feeding, competition, zone migration, and effects on other organisms. Each player receives 10 action cards, played in the third round, with effects that generally last one round unless the card states otherwise. Event cards depict natural events or environmental changes that can affect all players or specific zones on the ecosystem map; ten cards are played once in each five-round cycle, with effects that may benefit or harm players' organisms (Figure 3). The main guidebook contains the game's objectives, component descriptions, setup steps, gameplay flow, the scoring system, and a description of the STEM approach and the science process skills practiced in the game, while the player guidebook summarizes the gameplay steps for each player (Figure 4). After all components were designed and produced, the researchers arranged the overall layout of *Nest Boardgame* so that every part could be displayed as a single, ready-to-use product for the implementation stage (Figure 5).



Figure 3. Action Cards and Event Cards



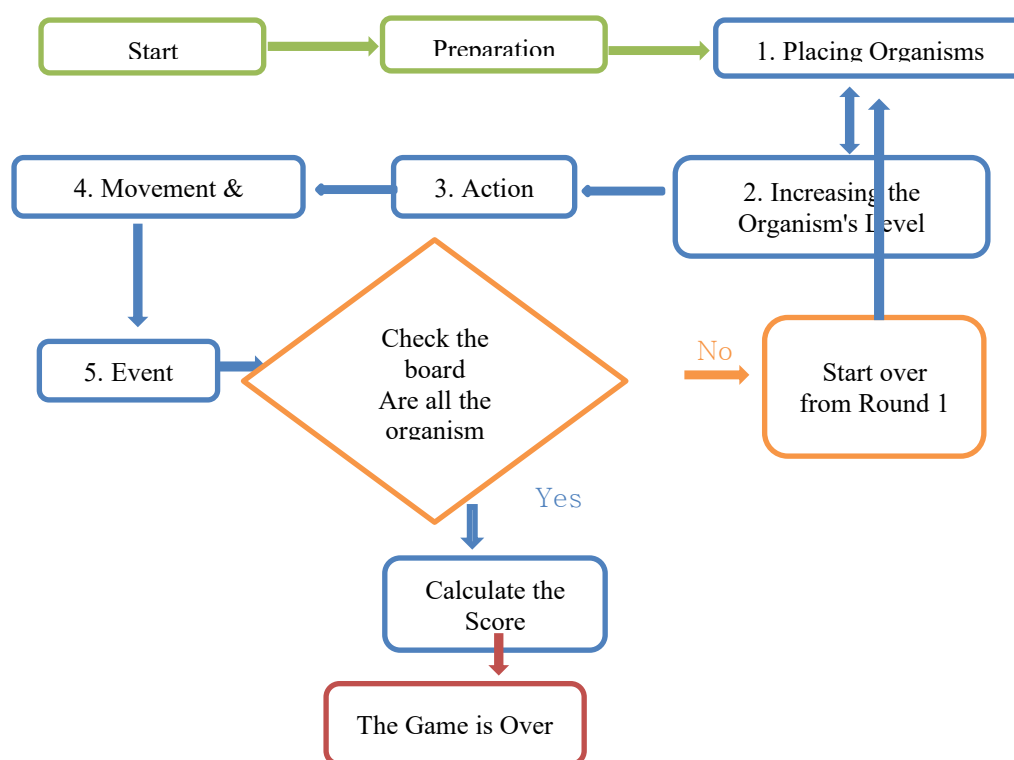
Figure 4. Main Guidebook and Player's Guidebook



Figure 5. *Nest Boardgame* Component Design and Layout

Nest Boardgame was designed so that STEM is not merely supplementary content but is integrated directly into the game mechanics, so that STEM thinking occurs while students play. This aligns with findings that experiential learning through game mechanics helps students connect what they learn to the world around them, because the consequences of each action encourage a more meaningful understanding of cause and effect (Refiyan & Rusdini, 2026). *The Science aspect* is embedded in interactions among organisms, such as the relationships among plants, herbivores, carnivores, and decomposers, where students learn to observe, identify, and predict the impact if an organism declines or disappears. *The Technology aspect* is reflected in the action-card and event-card system that changes game conditions, requiring students to read instructions, follow rules, observe changes on the ecosystem map, and adjust their next move. *The Engineering aspect* appears in designing and refining strategies to maintain ecosystem balance, including placing organisms, testing strategies, and revising them when disruptions occur. *The Mathematics aspect* is embedded in calculating energy use and scores, where students calculate, compare, and manage energy before making decisions.

The four STEM aspects are integrated through a game flow that begins with a preparation stage followed by five sequential rounds, each with a different focus. In the first round, Placing Organisms, which focuses on *Engineering* and *Science*, students choose placement zones by considering ecosystem relationships among plants, herbivores, carnivores, and decomposers. The second round, Increasing Levels, emphasizes *Engineering* and *Mathematics* as students select which organisms to level up based on the benefits gained. The third round, Action Cards, focuses on *Technology* and *Engineering*, as students read and carry out the card instructions and observe their impact on the game. The fourth round, Moving and Foraging, integrates *Science*, *Mathematics*, and *Engineering* through moving organisms, foraging, and calculating energy gains. The fifth round, Event Cards, emphasizes *Technology* and *Engineering* by simulating changing conditions such as natural disasters that require students to adjust their strategies. After the fifth round, students check the player board: if organism tokens remain, the game returns to the first round; if all tokens have been used, students count their scores and the game ends. Thus, *Engineering* is present in all five rounds, *Science* in the first and fourth rounds, *Mathematics* in the second and fourth rounds, and *Technology* in the third and fifth rounds, so that all four STEM domains are experienced repeatedly by students throughout the game. The overall flow of the game from start to finish is shown in Figure 6.

Figure 6. Flowchart (flow diagram) *Nest Boardgame*

The design was then realized as a physical product in the development stage and validated by eight expert validators (two language experts, three material experts, and three media experts) using a product validation sheet. The data were analyzed and converted into percentages to determine the product's feasibility category. The overall average of the three validation aspects was in the 81–100% range, categorized as Very Valid, meaning that *Nest Boardgame* is suitable for use in learning. The validation results are summarized in Table 4.

Table 4. Summary of *Nest Boardgame* Validation Results

Validation Aspects	Score Obtained	Max Score	Eligibility Percentage	Category
Language Expert	74	80	92.5%	Very Valid
Material Expert	101	105	96.2%	Very Valid
Media Expert	193	210	91.9%	Very Valid

All three aspects were categorized as Very Valid. This is consistent with previous research stating that learning media with validation scores of 81–100 are categorized as very valid and very suitable for use in learning (Yuliati & Wibawa, 2024). Similar results were reported in the development of fifth-grade mathematics media using the ADDIE model, which was assessed as very valid by media, material, and language experts (Aliyah & Nurafni, 2026). The highest score, for the material aspect (96.2%), indicates that the ecosystem content in *Nest Boardgame* is

aligned with the learning outcomes of Grade V, Phase C IPAS in the Merdeka Curriculum. The media validation score (91.9%) indicates that the physical components, from the ecosystem map board and action cards to the pawns and guidebook, meet the criteria for good learning media in appearance, readability, and ease of use. The language validation score (92.5%) indicates that the language in all components is communicative and appropriate for the developmental level of fifth-grade students. The validators also gave constructive feedback that served as the basis for product revisions. A summary of the feedback and the product changes before and after revision is presented in Table 5.

Table 5. Product Revisions Based on Validator Input

Before	Suggestions and Feedback	After
	The Forest Zone on the main game board should be recolored so it doesn't almost blend in with the background, perhaps try a brighter green.	
	Adding video tutorials via QR codes to the guidebook, changing the guide format into one integrated book that includes a game flow diagram from “start” to “finish”, and adding explanations about STEM.	
	Decomposer Action Card changes title “Move to Dead Material” to “Decompose the dead”	

Revision based on validators' input is an integral part of developing quality learning media because it improves the quality of the media to be used. With all validation results in the very valid category, *Nest Boardgame* was declared suitable for trial in the *implementation stage*. Practicality concerns the ease of use and suitability of the

media in real classroom learning; if the media are impractical, revisions are needed so they can be used optimally. The practicality of *Nest Boardgame* was assessed through response questionnaires completed by the students and one fifth-grade teacher after the small- and large-scale trials, while students' STEM engagement was measured with the STEM-based LKPD. The results are presented in Table 6.

Table 6. STEM Practicality and Engagement Results

Indicator	Small Scale (n = 4)	Category	Large Scale (n = 27)	Category
Student response	90.63%	Very Practical	90.16%	Very Practical
Teacher's response	80.56%	Very Practical	86.11%	Very Practical
STEM-based LKPD	84.37%	Very good	78.85%	Good

All student and teacher responses in both trials were in the Very Practical category, indicating that *Nest Boardgame* was easy to use and engaging for students in both small and larger groups. Similar positive responses were reported for the *Joyful Learning -based interactive science multimedia* for fourth-grade students, which was considered interesting, enjoyable, easy to use, and kept students motivated and engaged (Jannah et al., 2025). The increase in the teacher response score in the large-scale trial indicates that the improvements made after the small-scale trial, in both the clarity of the game instructions and the completeness of the components, enhanced the product's practicality from the teacher's perspective. The high positive student responses suggest that *Nest Boardgame* met the four ARCS motivation aspects: attention through an engaging board game design, relevance through an ecosystem context close to real life, confidence through mechanics that let every player contribute, and satisfaction through an enjoyable play experience.

The LKPD results were in the Very Good and Good categories, thus meeting the minimum criterion for STEM engagement. The lower result in the large-scale trial is understandable because larger groups have a wider range of abilities, whereas the small-scale result is more sensitive to individual scores because it involved only four students. Learning motivation was measured with an ARCS-based questionnaire administered before (*pre-test*) and after (*post-test*) the use of *Nest Boardgame*.

In the small-scale trial, student motivation was already in the Very High category at the pre-test and remained there at the post-test, with a moderate N-Gain. The mean score increased from 80.25 (SD = 8.261) to 90.00 (SD = 4.082) out of a maximum of 96. This difference was not statistically significant, which is understandable because the sample consisted of only four students, so the test had little power to detect differences. Nevertheless, no student's score decreased: three of the four students improved and one stayed the same. This positive trend is a promising initial indication for proceeding to the large-scale trial. The small-scale trial also produced technical feedback on the clarity of the game rules and the readability of the cards, which was used for improvements before the large-scale

trial. In the large-scale trial, the mean motivation score increased from 79.15 (SD = 7.639) to 85.22 (SD = 8.341) out of a maximum of 96. The Shapiro–Wilk test showed that the score differences were not normally distributed ($p = 0.039$), so the Wilcoxon Signed Ranks Test was used. The result ($Z = -3.677$; $p < 0.001$) showed a significant difference in learning motivation before and after using *Nest Boardgame*. Of the 27 students, 22 improved, 1 did not change, and 4 declined. Analysis by ARCS aspect showed significant increases in attention, confidence, and satisfaction, whereas relevance did not increase significantly. The largest increase occurred in satisfaction, while attention and relevance showed low-category gains because their initial scores were already high. The results of both trials, along with the breakdown by ARCS aspect in the large-scale trial, are presented in Table 7.

Table 7. Results of Learning Motivation in the Trial

Trial	Pre-test %	Post-test %	N-Gain	N-Gain Category	Asymp. Sig.
Overall					
Small scale (n = 4)	83.6	93.8	0.52	Moderate	0.109
Large scale (n = 27)	82.4	88.8	0.36	Moderate	< 0.001
Per Aspect					
ARCS (Large Scale)					
<i>Attention</i>	84.3	90.0	0.25	Low	0.002
<i>Relevance</i>	84.4	88.3	0.08	Low	0.099
<i>Confidence</i>	75.5	83.8	0.36	Moderate	< 0.001
<i>Satisfaction</i>	85.6	93.1	0.53	Moderate	0.001

The increase in motivation in the large-scale trial can be attributed to the characteristics of *Nest Boardgame*. Its competitive yet collaborative nature can sustain students' attention, in line with findings that innovative learning media increase learning enthusiasm compared with conventional learning (Maharani et al., 2024). The action-card mechanism, which places students in the real roles of living things in an ecosystem, makes learning feel relevant and contextual, in line with Refiyan and Rusdini's (2026) findings on experiential learning through games. Varied and enjoyable play can also reduce the boredom caused by monotonous lectures (Mutia et al., 2025), and *board games* are generally considered to facilitate analytical and collaborative learning and to increase active student engagement (Nilasari et al., 2026). From a cognitive development perspective, fifth-grade students in the concrete operational stage are more easily motivated by physical, interactive learning experiences that involve manipulating real objects (Susanto et al., 2024), so *board games* as a concrete, manipulative medium fits their developmental characteristics. This explanation remains interpretive because the study did not directly measure the causes of the increase in motivation.

The results by ARCS aspect give a more detailed picture of which motivational elements benefited most. The largest increase, in satisfaction, indicates that finishing the game and completing the LKPD gave students a sense of satisfaction with their efforts, in line with the ARCS principle that satisfaction arises when

learning effort is followed by tangible results (Darmansyah, 2023) . Confidence grew from the lowest starting point among the four aspects, indicating that the full play experience helped students feel capable of mastering the material and the game rules. In contrast, relevance did not increase significantly ($p = 0.099$). This is probably because students began to recognize the link between ecosystem material and everyday life during the initial simulation, so further improvement after full play was limited. However, a high initial score (84,4%; N-Gain 0,08) this does not fully explain these findings because *satisfaction* also stems from a high initial score (85,6%) but showed the greatest increase. This difference suggests that *relevance* is determined more by the content and context of the material on the cards which remain unchanged throughout the entire game, unlike *satisfaction* which is shaped by the experience of completing the game. The small sample size ($n = 27$) may also have made the test less sensitive to small improvements. Practically, the design of subsequent cards and materials needs to link ecosystems more directly to students' surroundings, for example, through examples of local organisms and habitats in East Kalimantan on action cards, *event cards* containing real-life events such as floods or fires, and trigger questions that connect events in the game to students' daily experiences.

The overall increase in motivation was in the moderate category, not high. One reason is that students' initial scores were already in the Very High category, which limited room for improvement. Four students' scores also declined, and individual factors that might have influenced this, such as their experience during the game, were not analyzed in this study. Thus, *Nest Boardgame* can be considered moderately effective in supporting learning motivation overall but does not guarantee improvement for every student. Several limitations should be noted. First, *the pre-test* was administered after a brief simulation, so the reported improvement reflects a change from initial impressions after the simulation to the full play experience rather than from a no-exposure condition; this may also explain the high initial scores. Second, six students gave uniform answers to all *pre-test items*, making their responses less consistent; an analysis without these six students still showed a significant improvement ($Z = -3.500$; $p < 0.001$). Third, the *one-group pretest-posttest design* without a control class makes it impossible to attribute the increase in motivation solely to the media, because other factors such as the novelty effect and familiarity with the same questionnaire may have played a role. The study was also conducted in a single class with a small sample, only one teacher provided responses, and the LKPD was scored by the researcher. Future research should use a control class, a pre-test without prior exposure, and a larger sample. These findings could also be extended to other IPAS topics involving systems and interactions, such as the water cycle or changes in the state of matter.

4. Conclusion

This study aimed to develop *Nest Boardgame* as a STEM-based learning medium on the Harmony in Ecosystems topic and to test its feasibility for supporting the learning motivation of fifth-grade elementary school students. Using the ADDIE model, the product was rated very valid by language, material, and media experts

and very practical based on student and teacher responses in both trials. LKPD achievement was in the good to very good category, indicating that the medium can facilitate student engagement in STEM activities. In the large-scale trial, learning motivation increased significantly with a moderate improvement category, especially in *attention*, *confidence*, and *satisfaction*, so *Nest Boardgame* was considered moderately effective in supporting learning motivation. Thus, the research objective was achieved, although *the relevance aspect* has not increased significantly so it still needs to be strengthened in the card design. These findings indicate that integrating STEM into board game mechanics can provide an engaging alternative IPAS learning medium suited to elementary school students. For elementary school teachers, *the Nest Boardgame* is recommended as a reinforcement medium for the Harmony in Ecosystem material by dividing students into small groups guided by one referee student, starting with a short simulation to introduce the rules, and ending with a STEM-based Student Worksheet. Teachers can also add examples of students' surroundings on the cards to strengthen the connection of the material to everyday life. Because this study used a single-group design with a limited sample, future research should use a control class and a larger sample, examine effects on other variables such as cognitive learning outcomes and collaboration skills, and extend the medium to other topics and grade levels.

Acknowledgments

The authors thank SD Negeri 008 Samarinda Ilir for permission and support in conducting the research, the language, material, and media expert validators for their constructive input, and the fifth-grade students who participated in the trials. This research received no specific funding from any institution.

References

- Aisah, R. N., Armariena, D. N., & Marleni. (2024). Pengembangan Board Game untuk Meningkatkan Minat Belajar Siswa. *Jurnal Pembahsi (Pembelajaran Bahasa Dan Sastra Indonesia)*, 14(2), 156–162. <https://doi.org/10.31851/pembahsi.v14i2>
- Aliifah, N. J., Ramli, M., & Yunita, L. (2023). Pengembangan Media Pembelajaran Komik Webtoon Terintegrasi STEM pada Mata Pelajaran Kimia Materi Gaya Antarmolekul. *SPIN Jurnal Kimia & Pendidikan Kimia*, 5(1), 112–126. <https://doi.org/10.20414/spin.v5i1.7020>
- Aliyah, F. J., & Nurafni, N. (2026). Development of Assemblr EDU Platform to Increase Spatial Literacy for Grade V Elementary Students in Geometry. *Journal of Educational Sciences*, 10(9), 69–84. <https://doi.org/10.31258/jes.10.9.hal.69-84>
- Condong, D. M., Sihalohe, M., & Thayban, T. (2026). Uji N-Gain pada Implementasi STEM pada Model Pembelajaran Problem Based Learning terhadap Keterampilan Berpikir Kritis. *Jurnal Entropi*, 21(1), 15–21. <https://doi.org/10.37905/je.v21i1.37561>
- Darmansyah. (2023). *Model-Model Desain Instruksional*. PT. RajaGrafindo Persada - Rajawali Pers.

-
- Effendi, R., Herpratiwi, H., & Sutiarto, S. (2021). Pengembangan LKPD Matematika Berbasis Problem Based Learning di Sekolah Dasar. *Jurnal Basicedu*, 5(2), 920–929. <https://doi.org/10.31004/basicedu.v5i2.846>
- Erinsyah, M. F., Sasmito, G. W., Wibowo, D. S., & Bakti, V. K. (2024). Sistem Evaluasi pada Aplikasi Akademik Menggunakan Metode Skala Likert dan Algoritma Naïve Bayes. *Komputa: Jurnal Ilmiah Komputer Dan Informatika*, 13(1), 74–82. <https://doi.org/10.34010/komputa.v13i1.10940>
- Fadhillah, F., & Octarya, Z. (2023). Pengembangan Media Pembelajaran Interaktif Menggunakan Articulate Storyline 3 pada Materi Larutan Elektrolit dan Non Elektrolit. *Konfigurasi: Jurnal Pendidikan Kimia Dan Terapan*, 07(1), 31–42. <https://doi.org/10.24014/konfigurasi.v7i1.21556>
- Flamonia, P., Hasanah, L., & Suwarma, I. R. (2026). Research Skills of High School Students in STEM Learning: An Analysis Using the Research Skill Development Framework. *Journal of Educational Sciences*, 10(9), 282–297. <https://doi.org/10.31258/jes.10.9.hal.282-297>
- Indrawati, E. S., Yessari, M., & Afia, B. (2025). Transformasi Pembelajaran Sains di Sekolah Dasar melalui Pendekatan Inkuiri, PBL, PjBL, dan STEM dalam Menumbuhkan Keterampilan Abad Ke-21. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 10(4), 257–268. <https://doi.org/10.23969/jp.v10i04.38667>
- Jannah, M., Febriyanti, F., & Saputra, M. A. (2025). Development of Joyful Learning-Based Interactive Multimedia in IPAS to Improve Conceptual Understanding and Learning Activities of Elementary School Students. *Journal of Educational Sciences*, 9(6), 6095–6109. <https://doi.org/10.31258/jes.9.6.p.6095-6109>
- Maharani, A. S., Nasuha, S. U., & Maulida, S. R. (2024). Media Pembelajaran sebagai Alternatif Meningkatkan Gairah Belajar. *Jurnal Bionatural*, 11(2), 76–83.
- Mawarni, J., & Hendriyani, Y. (2021). Pengembangan Media Pembelajaran E-Modul Interaktif pada Matakuliah Pemrograman Visual dengan Metode Pengembangan ADDIE. *Jurnal Vokasi Informatika*, 1(3), 79–88. <https://doi.org/10.24036/javit.v1i3.67>
- Mutia, N., Sismia, T. N. Z., Ramadhani, K. R., & Suryapuspita, A. (2025). Perbandingan Motivasi Belajar Siswa melalui Metode Ceramah dan Digital. *Jurnal Pendidikan Dan Pembelajaran*, 4(2), 2514–2520.
- Nilasari, N. P. L., Wiguna, I. K. W., & Tristaningrat, M. A. N. (2026). Boardgame sebagai Media Inovatif dalam Meningkatkan Keterampilan Berpikir Kritis Siswa Sekolah Dasar. *JiIP - Jurnal Ilmiah Ilmu Pendidikan*, 9(1), 1076–1080. <https://doi.org/10.54371/jiip.v9i1.10412>
- Nofriza, Y., & Zen, Z. (2024). Analysis Validation and Practicality of Crossword Puzzle Learning Media in Science Subjects for Class VII in Junior High Schools. *Jurnal Penelitian Pendidikan IPA*, 10(6), 2891–2897. <https://doi.org/10.29303/jppipa.v10i6.7489>
- Nugroho, C. I., Septika, H. D., & Muhlis, M. (2024). Pengembangan Eduvane (E-Modul Canva dan Heyzine) pada Materi Fakta dan Opini di Kelas V SDN 011 Samarinda Kota Tahun Pembelajaran 2023/2024. *Jurnal Basataka (JBT)*, 7(2), 534–548. <https://doi.org/10.36277/basataka.v7i2.484>
- Patras, Y. E., Yolanita, C., Wildan, D. A., & Fajrudin, L. (2024). Pembelajaran
-

- Berbasis STEM di Sekolah Dasar guna Meningkatkan Kemampuan Berpikir Kritis dalam rangka Menyongsong Pencapaian Kompetensi Siswa Abad 21. *Kalam Cendekia: Jurnal Ilmiah Kependidikan*, 12(2), 857–867. <https://doi.org/10.20961/jkc.v12i2.87662>
- Permatasari, D., Karim, A., & Sati. (2026). Optimizing Science Learning Outcomes Through the Use of Pop-Up Books Among Elementary School Students. *Journal of Educational Sciences*, 10(8), 442–454. <https://doi.org/10.31258/jes.10.8.hal.442-454>
- Pinkan, D., & Yatri, I. (2026). The Influence of Audiovisual Media on the IPAS Learning Outcomes of Fifth-Grade Elementary School Students. *Journal of Educational Sciences*, 10(9), 101–118. <https://doi.org/10.31258/jes.10.9.hal.101-118>
- Purwanti, C. I., & Fanani, A. (2024). Pengembangan Media Digital Interaktif Pendukung Kelompok Kinestetik pada Materi Perubahan Wujud Benda pada Siswa Sekolah Dasar. *Jurnal Studi Guru Dan Pembelajaran*, 7(1), 201–210. <https://doi.org/10.30605/jsjp.7.1.2024.3591>
- Rahmani, C. D., Adrias, A., & Suciana, F. (2025). Penggunaan Media Pembelajaran Berbasis Teknologi dalam Pembelajaran IPAS di Sekolah Dasar. *Sinar Dunia: Jurnal Riset Sosial Humaniora Dan Ilmu Pendidikan*, 4(1), 268–278. <https://doi.org/10.58192/sidu.v4i1.3193>
- Rahmawati, Q. A. D., & Adanti, L. N. (2023). Pengembangan Media Pop-Up Book untuk Meningkatkan Motivasi Belajar Siswa pada Materi Harmonisasi dalam Ekosistem di Kelas V Sekolah Dasar. *Journal of Best Practice*, 1(1), 66–72.
- Refiyan, T. P., & Rusdini, S. E. (2026). Implementasi Board Game “Climate Race” sebagai Media Pembelajaran IPS untuk Memperkuat Karakter Peduli Lingkungan Siswa SMPN 12 Semarang. *Jurnal Studi Guru Dan Pembelajaran*, 9(2), 617–630. <https://doi.org/10.30605/jsjp.9.2.2026.8161>
- Rosmawati, E., Nugraha, U., & Sulistiyo, U. (2024). Penggunaan Media Diorama untuk Meningkatkan Motivasi dan Hasil Belajar Siswa pada Materi Harmoni dalam Ekosistem Mata Pelajaran IPAS Kelas V Sekolah Dasar Negeri 153/X Harapan Makmur. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 9(4), 918–926. <https://doi.org/10.23969/jp.v9i04.20191>
- Rusnah, R., Boimau, M. S., & Duka, M. R. C. (2024). Boardgame Gameko: Mengubah Pembelajaran Ekosistem Kelas 5 Menjadi Pengalaman Belajar yang Asyik. *Jurnal Media Edukasi Dan Pembelajaran*, 2(1), 65–68.
- Sapitri, N. K. I., Ardana, I. M., & Gunamantha, I. M. (2022). Pengembangan LKPD Berbasis Pemecahan Masalah dengan Pendekatan 4C untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *PENDASI: Jurnal Pendidikan Dasar Indonesia*, 6(1), 24–32. https://doi.org/10.23887/jurnal_pendas.v6i1.537
- Sari, U. A., Nadiroha, W., Adrias, A., & Syam, S. S. (2025). Analisis Faktor Rendahnya Motivasi Belajar Siswa dalam Mata Pelajaran IPA di Sekolah Dasar. *Natural Science Education Research*, 8(1), 111–116. <https://doi.org/10.21107/nser.v8i1.29635>
- Sari, W. N., & Fajrie, N. (2023). Analisis Kebutuhan Media Pembelajaran dalam Materi Pembelajaran Ekosistem untuk Kelas V SD di Kecamatan Winong Kabupaten Pati Jawa Tengah. *JlIP - Jurnal Ilmiah Ilmu Pendidikan*, 6(4), 2472–2480. <https://doi.org/10.54371/jiip.v6i4.1594>

- Suhartini, E., & Haerani, R. P. R. (2022). Development of STEM Based E-Modules About Socioscientific Issues The East Kalimantan Tropical Rainforest. *Edusains*, 14(2), 137–147. <https://doi.org/10.15408/es.v14i2.28745>
- Supriyatna, Y., Suhartini, E., Zahra, I. R., Mannan, M. N., & Khaerani, R. P. R. (2025). Analisis Implementasi Pendekatan STEM dalam Pembelajaran IPA di Sekolah Dasar: Studi Kontekstual di Kota Samarinda. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 10(4), 368–380. <https://doi.org/10.23969/jp.v10i04.31500>
- Susanto, A. H., Wulandari, M. D., & Darsinah. (2024). Optimalisasi Pembelajaran Anak Usia Sekolah Dasar melalui Pemahaman Teori Perkembangan Kognitif Jean Piaget. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 9(4), 689–706. <https://doi.org/10.23969/jp.v9i4.17102>
- Wibawanto, W. (2024). *Board Game Edukasi*. CV. Idebuku.
- Widyaningrum, D., Smaragdina, A. A., Rizky, D. D., Ardiansyah, Y. E., & Prasasti, F. A. M. (2025). Meningkatkan Motivasi Belajar Siswa Menggunakan Zep Quiz pada Pembelajaran Informatika di SMP. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 10(2), 200–211. <https://doi.org/10.23969/jp.v10i02.28792>
- Yanuar, M., & Sari, F. A. (2025). Tingkat Kesiapan dan Tantangan Calon Guru Sekolah Dasar dalam Menyusun Modul Ajar Berbasis Kurikulum Merdeka. *Tunas: Jurnal Penelitian Pendidikan Dasar*, 2(1), 44–55.
- Yulianto, R. R. (2026). Analisis Implementasi Model ADDIE dalam Perencanaan dan Pengembangan Pembelajaran Inovatif. *An-Nahdloh: Journal of Education and Islamic Studies*, 1(2), 306–318. <https://doi.org/10.58788/jeis.v1i2.25>
- Yuliati, N. W., & Wibawa, S. (2024). Pengembangan Media Belajar Interaktif LKPD Berbasis Liveworksheet pada Mata Pelajaran PKn Kelas 6 SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 9(3), 827–838. <https://doi.org/10.23969/jp.v9i03.16134>
- Zahra, I. R., Kurniati, N., Mannan, M. N., & Supriyatna, Y. (2025). Pemahaman Kurikulum Merdeka di Pendidikan Keguruan: Studi pada Calon Guru Sekolah Dasar. *Tunas: Jurnal Penelitian Pendidikan Dasar*, 2(1), 1–13.

How to cite this article:

Khairunisa, N. C., Suhartini, E., & Ramla. (2026). Development of a STEM-Based Board Game "Nest" on the Harmony in Ecosystems Subject to Support Fifth Grade Elementary School Students' Learning Motivation. *Journal of Educational Sciences*, 10(10), 673-692.