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Development of the Harmoni Smart Box Learning Media to Enhance Fifth-Grade Students' Conceptual Understanding of Ecosystems

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Abstract: This study aimed to develop the Harmoni Smart Box Learning Media, an interactive instructional medium that integrates a three-dimensional ecosystem model, ecosystem concept cards, environmental problem cards, and student-centered exploratory activities to support students' conceptual understanding. The study employed a Research and Development (R&D) approach based on the ADDIE model. Before classroom implementation, the product was validated by experts in science content, instructional media, pedagogy, and research instrument development. A limited field trial using a one-group pretest–posttest design was subsequently conducted with 32 fifth-grade students at SDN Tengah 03 Jakarta. Product feasibility was assessed using expert validation questionnaires, whereas students' conceptual understanding was measured through pretest and posttest assessments. The expert validation results showed that the developed learning media achieved a very high level of feasibility across all evaluated aspects. Students' conceptual understanding also improved after using the media, and the Wilcoxon signed-rank test revealed a statistically significant difference between the pretest and posttest scores ($p < 0.05$). These findings indicate that the Harmoni Smart Box Learning Media is highly feasible for use in elementary science instruction and shows promising potential to support students' conceptual understanding in a limited classroom setting. Nevertheless, further studies involving larger and more diverse samples, as well as control groups, are required to evaluate its instructional effectiveness more comprehensively.
Keywords: Conceptual understanding; ecosystem; elementary science; Harmoni Smart Box Learning Media; instructional media

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INTRODUCTION

Integrated Natural and Social Sciences (Ilmu Pengetahuan Alam dan Sosial [IPAS]) instruction in Indonesian elementary schools aims to develop students' conceptual understanding, scientific reasoning, environmental awareness, and problem-solving skills by connecting scientific knowledge with real-life experiences. Through meaningful learning activities, students are expected not merely to acquire factual knowledge but also to explain scientific phenomena, identify relationships among concepts, and apply their knowledge to everyday situations (Qomara et al., 2024; Rachmania et al., 2025).

Despite these objectives, the implementation of IPAS instruction in elementary schools continues to face substantial challenges. Classroom instruction remains predominantly teacher-centered and relies heavily on textbooks and verbal explanations, providing students with limited opportunities to observe phenomena, explore scientific ideas, and construct knowledge independently. Such instructional conditions may reduce students' motivation and hinder their ability to connect scientific concepts with authentic environmental phenomena (Atikah et al., 2023; Kuroru & Rahmah, 2023). Consequently, students may rely on memorizing isolated facts without adequately understanding the relationships among ecosystem components, resulting in limited conceptual understanding.

Preliminary classroom observations and an interview with the fifth-grade teacher at SDN Tengah 03 Jakarta confirmed these instructional challenges. Many students experienced difficulty explaining ecosystem concepts, distinguishing between biotic and abiotic components, describing food chains, and understanding ecosystem balance. The teacher also reported that ecosystem instruction relied primarily on textbooks and oral explanations because interactive learning media were unavailable. Consequently, students tended to participate passively in classroom activities and demonstrated a limited understanding of the interactions and processes that occur within ecosystems.

Understanding ecosystems requires students to reason about interconnected structures, interactions, processes, and changes rather than merely identify individual components. Because ecosystems function as complex systems, students must understand how changes in one component can affect other organisms and the overall balance of the system (Hmelo-Silver et al., 2007; Eberbach et al., 2021). From a Piagetian perspective, although cognitive development varies among individual learners, fifth-grade students commonly benefit from instruction that connects abstract scientific ideas with concrete representations and direct experiences (Piaget & Inhelder, 1969). The Interactive–Constructive–Active–Passive framework further suggests that learning becomes deeper as students progress from passively receiving information to actively manipulating materials, constructing explanations, and interacting with others to develop shared understanding (Chi & Wylie, 2014). Therefore, instructional media that incorporate visual representations, hands-on activities, guided exploration, and collaborative discussion are particularly relevant to ecosystem learning at the elementary-school level.

Previous studies have reported that Smart Box learning media can enhance students' motivation, classroom engagement, conceptual understanding, and learning outcomes in elementary science education. By providing visual and interactive learning experiences, these media encourage students to participate actively in the learning process (Saofah et al., 2024; Utami et al., 2025; Simanjuntak et al., 2025). Smart Box media developed using the Science–Environment–Technology–Society (SETS) approach have also been reported to support students' conceptual understanding and classroom participation (Saofah et al., 2024). Similarly, interactive Smart Box media can increase student engagement and facilitate a more concrete understanding of scientific concepts (Aini et al., 2025). Collectively, these studies demonstrate the potential of Smart Box media to create more active and meaningful elementary science learning experiences.

Nevertheless, important research gaps remain. Previous Smart Box studies have largely emphasized students' motivation, general learning outcomes, or classroom participation. Although some studies have examined conceptual understanding, limited attention has been given to how an integrated Smart Box can support relational and systems-level understanding of ecosystems, including interactions among biotic and abiotic components, food-chain relationships, environmental disturbances, and ecosystem balance. Furthermore, previously reported Smart Box media generally do not combine a three-dimensional ecosystem model, ecosystem concept cards, environmental problem cards, and structured collaborative exploration within a single instructional medium. Thus, further development is required to provide students with opportunities not only to recognize ecosystem components but also to explain relationships, analyze environmental problems, and apply ecosystem concepts to authentic situations.

To address these gaps, the present study developed the Harmoni Smart Box Learning Media, an interactive instructional medium specifically designed for ecosystem learning. The medium integrates a three-dimensional ecosystem model, ecosystem concept cards, environmental problem cards, Read Me cards, and collaborative student activities. These components guide students through a structured learning sequence involving observation, classification, discussion, conceptual construction, environmental problem analysis, and the application of ecosystem concepts to real-life situations. Unlike Smart Box media that primarily present learning content or practice activities, the Harmoni Smart Box Learning Media was designed to support students in explaining relationships and causal processes within ecosystems. The integration of these visual, manipulative, problem-based, and collaborative components constitutes the principal novelty of the developed product.

Accordingly, this study aimed to: (1) develop the Harmoni Smart Box Learning Media for fifth-grade ecosystem instruction; (2) evaluate its feasibility through expert validation and a small-group trial; and (3) examine changes in students' conceptual understanding during a limited classroom implementation. For the classroom trial, it was hypothesized that students would demonstrate higher conceptual-understanding scores after learning with the Harmoni Smart Box Learning Media than before its implementation. However, because the study employed a one-group pretest–posttest design without a control group, any observed improvement was interpreted as preliminary evidence of the media's potential contribution rather than conclusive evidence of instructional effectiveness.

METHOD

Research Design and Development Procedure

This study employed a Research and Development (R&D) approach based on the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic framework for designing, developing, validating, implementing, and evaluating instructional media. This study aimed to develop the Harmoni Smart Box Learning Media for ecosystem instruction and assess its feasibility for fifth-grade Science and Social Studies (IPAS) learning. Following product development, the media were implemented using a one-group pretest–posttest design to examine their potential contribution to students' conceptual understanding.

During the Analysis stage, classroom observations, teacher interviews, curriculum analysis, and a literature review were conducted to identify students' learning difficulties, characteristics, and instructional needs related to ecosystem concepts. The results indicated that many students experienced difficulty distinguishing between biotic and abiotic components, explaining food chains and food webs, and understanding ecosystem balance. Classroom instruction relied primarily on textbooks and teacher explanations, with limited use of interactive learning media. These findings provided the basis for developing the Harmoni Smart Box Learning Media.

The Design stage involved formulating the learning objectives, organizing the ecosystem content, developing learning indicators, designing the layout and instructional components of the media, preparing student learning activities, constructing the conceptual understanding test, and developing the expert validation instruments.

During the Development stage, the Harmoni Smart Box Learning Media was produced by integrating several instructional components into a single learning

medium. These components included a three-dimensional ecosystem model, ecosystem concept cards, environmental problem cards, Read Me cards, student activity cards, and supporting learning materials. The product was subsequently evaluated by four experts: a subject-matter expert, an instructional media expert, a pedagogical expert, and an educational assessment expert. Based on their recommendations, the product was revised to improve the clarity of the instructional language, visual presentation, layout, and content of several concept cards. These revisions were also intended to ensure alignment between the media components and the learning objectives before classroom implementation.

During the Implementation stage, the revised product was initially evaluated through a small-group trial involving five fifth-grade students. This preliminary trial assessed the usability of the product, the clarity of its instructions, the attractiveness of its design, and the practicality of the learning activities. Student feedback was used to make minor revisions, particularly to improve instructional clarity, the organization of the media components, and the readability of several learning cards.

Following these revisions, the final version of the Harmoni Smart Box Learning Media was implemented in a limited field trial involving 32 fifth-grade students at SDN Tengah 03 Jakarta. The participants were selected using total sampling. Before the learning activities began, the students completed a pretest to assess their initial conceptual understanding of ecosystem concepts. During instruction, they interacted directly with the learning media by observing the ecosystem model, identifying biotic and abiotic components, analyzing food chains and ecosystem balance, discussing environmental issues, completing collaborative activities, and responding to tasks presented on the ecosystem concept cards. At the end of the instructional session, the students completed a posttest based on the same conceptual understanding indicators.

The Evaluation stage was conducted continuously throughout the development process. Formative evaluation included expert validation, the small-group trial, and product revisions based on feedback from both experts and students. Summative evaluation was conducted during the limited field trial by comparing students' conceptual understanding before and after the use of the developed learning media. Feedback collected throughout these stages was used to refine the final version of the Harmoni Smart Box Learning Media.

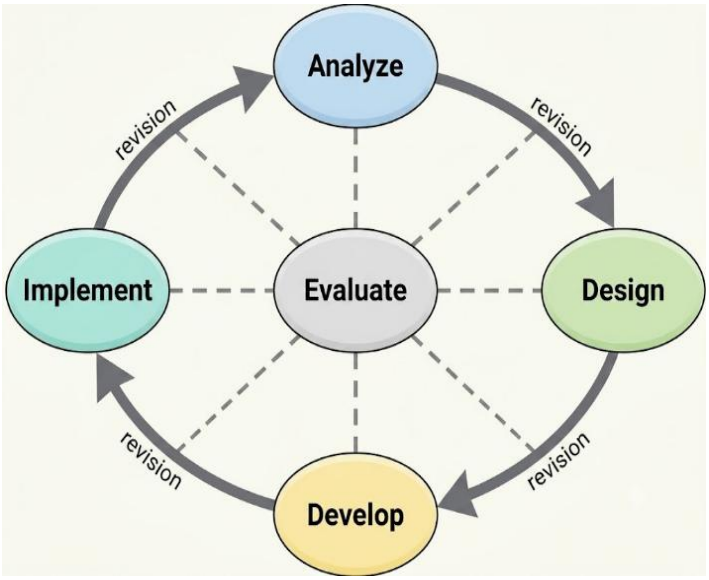

Figure 1. Stages of the ADDIE development model

Participants

The participants comprised four expert validators, five fifth-grade students who took part in the small-group trial, and 32 fifth-grade students who participated in the limited field trial. The experts evaluated the feasibility of the learning media in terms of science content, instructional media design, pedagogical appropriateness, and educational assessment. The five students involved in the small-group trial provided feedback on the usability and practicality of the media, whereas the 32 students participated in the classroom implementation to examine the media's potential contribution to their conceptual understanding.

Research Instruments

The research instruments consisted of observation and interview guidelines, expert validation questionnaires, student-response observation sheets used during the small-group trial, and a conceptual understanding test. The observation and interview guidelines were used during the needs analysis to identify instructional problems in the classroom.

The expert validation questionnaires contained assessment indicators related to content quality, media design, pedagogical appropriateness, and the quality of the assessment instruments. Each item was rated on a five-point Likert scale ranging from 1 (very poor) to 5 (excellent).

The conceptual understanding test was developed based on ecosystem learning indicators. These indicators included identifying ecosystem components, explaining interactions among organisms, analyzing food chains and food webs, describing ecosystem balance, and applying ecosystem concepts to real-life situations. Students' responses were evaluated using predetermined scoring guidelines, with higher scores indicating a greater level of conceptual understanding.

Data Analysis

Expert validation data were analyzed using descriptive quantitative methods. The scores obtained from the validators were converted into percentages and interpreted according to predetermined feasibility criteria. Feedback from the small-group trial was analyzed descriptively and used to refine the product before the limited field trial.

Students' conceptual understanding was analyzed by comparing their pretest and posttest scores. Before hypothesis testing, the score distributions were examined for normality. Because the data did not satisfy the assumption of normality, the Wilcoxon signed-rank test was used to determine whether the difference between the pretest and posttest scores was statistically significant. The significance level was set at ($p < 0.05$).

Because the study involved only one class and did not include a control group, the results were interpreted as preliminary evidence of the potential contribution of the Harmoni Smart Box Learning Media within a limited classroom trial rather than as conclusive evidence of its instructional effectiveness.

RESULTS AND DISCUSSION

Product Development

The Harmoni Smart Box Learning Media was developed using the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The development process began with a needs analysis based on classroom observations, teacher interviews, curriculum analysis, and a review of relevant studies. The analysis showed that fifth-grade students experienced difficulties in understanding ecosystem concepts, particularly in distinguishing between biotic and

abiotic components, explaining food chains and food webs, and understanding ecosystem balance. Classroom instruction relied primarily on textbooks and teacher explanations, providing students with limited opportunities to engage in hands-on learning. These findings highlighted the need for an instructional medium that could represent abstract ecosystem concepts through concrete and interactive learning experiences.

These findings are consistent with Kuroru and Rahmah (2023), who reported that elementary school students commonly experience cognitive difficulties when learning ecosystem concepts. Similar challenges have also been identified in students' understanding of ecosystem components and interactions, particularly when instruction emphasizes factual recall rather than conceptual relationships (Sudianto & Rosyadi, 2024). Therefore, the use of concrete and interactive learning materials is particularly relevant because such materials can help students connect abstract scientific concepts with observable representations and direct learning experiences (Ardana & Wiyasa, 2020).

In response to these needs, the Harmoni Smart Box Learning Media was designed as an interactive learning package integrating several instructional components, including a three-dimensional ecosystem model, ecosystem concept cards, environmental problem cards, Read Me cards, and student activity cards. The Read Me component comprises explanatory cards presenting essential ecosystem concepts and question cards that encourage students to analyze environmental problems, discuss ideas collaboratively, and apply scientific concepts to real-life situations.

Unlike previously developed Smart Box media, which have generally focused on improving learning motivation or academic achievement, the Harmoni Smart Box Learning Media was specifically designed to facilitate conceptual understanding by integrating visual representations, concrete manipulatives, and collaborative learning activities.

The integration of these components extends previous Smart Box developments by placing greater emphasis on concept construction and the application of ecosystem knowledge. Previous studies have shown that Smart Box media can promote active participation and provide visual and interactive learning experiences in elementary science classrooms (Saofah et al., 2024; Aini et al., 2025). The present product expands this function by combining three-dimensional representations, conceptual classification activities, environmental problem-solving tasks, and collaborative discussion within a single instructional package. This integrated design allows students not only to recognize ecosystem components but also to examine the relationships among organisms, environmental conditions, and ecosystem balance.

Before classroom implementation, four expert validators evaluated the prototype. Based on their recommendations, the product was revised to improve its instructional quality. The revisions included refining the instructional language, enhancing visual consistency, improving font readability, reorganizing the layout of the learning components, and revising several ecosystem concept cards to ensure conceptual accuracy and alignment with the intended learning objectives.

Following expert validation, the revised prototype was evaluated in a small-group trial involving five fifth-grade students. This trial assessed the usability of the product, the clarity of its instructions, the attractiveness of the learning medium, and the practicality of the learning activities. Overall, the students responded positively to the product and were able to use its components appropriately during the learning activities. Minor revisions were subsequently made in response to student feedback,

including clarifying several instructions and rearranging selected learning components to facilitate their use in the classroom. The final version of the Harmoni Smart Box Learning Media was then prepared for implementation in the limited field trial.

The small-group trial was an important part of the development process because it allowed the researchers to identify practical difficulties that may not have been detected during expert validation. This procedure is consistent with the iterative nature of research and development, in which products are repeatedly evaluated and refined before broader implementation (Waruwu, 2024). The students' positive responses also suggest that the visual and manipulable components were appropriate for their learning characteristics and could support active engagement during ecosystem instruction.

Figure 2. The developed Harmoni Smart Box for ecosystem learning

The developed learning medium provides students with structured opportunities to observe, manipulate, discuss, and solve ecosystem-related problems. These integrated features constitute the primary novelty of the product and are intended to support meaningful learning experiences appropriate for elementary school students.

By linking ecosystem concepts with concrete representations and environmental problems, the medium may help students organize knowledge more systematically and apply it beyond the immediate classroom context. This feature is particularly important in ecosystem learning because conceptual understanding requires students to recognize not only individual components but also the interdependence among living organisms and their physical environment.

Expert Validation

The feasibility of the Harmoni Smart Box Learning Media was assessed by four experts specializing in science content, instructional media, pedagogy, and educational assessment. Before classroom implementation, the validation process examined the scientific accuracy of the content, the quality of the instructional media design, the pedagogical appropriateness of the learning activities, and the quality of the assessment instruments.

Table 1. Expert validation results

Validation Aspect	Percentage (%)	Category
Science Content Expert	91%	Highly Feasible
Instructional Media Expert	80%	Highly Feasible
Pedagogical Expert	96%	Highly Feasible
Educational Assessment Expert	80%	Highly Feasible
Average	**86.75%**	**Highly Feasible**

As shown in Table 1, the Harmoni Smart Box Learning Media achieved an average feasibility score of 86.75%, placing it in the highly feasible category for classroom implementation. The science content expert confirmed that the ecosystem content was scientifically accurate and aligned with the curriculum. The instructional media expert recommended improvements to the layout, font readability, and visual consistency. The pedagogical expert indicated that the learning activities were appropriate for students at the concrete operational stage because they encouraged active participation through observation and discussion. The educational assessment expert recommended revising several test items to improve their clarity and strengthen their alignment with the indicators of conceptual understanding. All recommendations were incorporated into the revised product before classroom implementation.

The highest validation score was obtained for the pedagogical aspect, indicating that the learning activities were considered appropriate for the developmental and instructional needs of fifth-grade students. The strong material-validation score also suggests that the ecosystem content was accurate and aligned with the intended learning objectives. These results support the use of concrete, visual, and student-centered materials in elementary science instruction, as similar approaches have been reported to facilitate active participation and support the understanding of scientific concepts (Ardana & Wiyasa, 2020; Saofah et al., 2024).

The comparatively lower scores for instructional media and educational assessment do not indicate that the product was unsuitable; rather, they identify areas requiring further refinement. Improvements in layout, readability, visual consistency, and test-item alignment were therefore necessary to ensure that the instructional components communicated the intended concepts clearly. This refinement is important because the quality of instructional media depends not only on the accuracy of its content but also on the accessibility of its visual design and the alignment between learning objectives, activities, and assessment.

These findings indicate that the Harmoni Smart Box Learning Media met the established quality criteria for classroom use. Nevertheless, expert validation provides evidence of product feasibility rather than instructional effectiveness. A limited classroom trial was therefore conducted to examine the potential contribution of the learning medium to students' conceptual understanding.

Student Learning Outcomes

Following expert validation and product revision, the Harmoni Smart Box Learning Media was implemented in a limited classroom trial involving 32 fifth-grade students. The students completed a pretest before participating in the learning activities and a posttest after learning with the developed medium. Both assessments measured their conceptual understanding of ecosystem concepts.

Table 2. Summary of student learning outcome data

Assessment	N	Mean	Standard Deviation	Measurement Stage
Pretest	32	258.91	217.16	Before the intervention
Posttest	32	492.19	377.63	After the intervention

As presented in Table 2, the mean score increased from 258.91 on the pretest to 492.19 on the posttest following the classroom implementation. The higher posttest mean indicates an overall improvement in students' conceptual understanding after learning with the Harmoni Smart Box Learning Media. However, the larger posttest

standard deviation indicates greater variability in student performance, suggesting that the learning medium did not affect all students to the same extent.

The increase in the mean score suggests that the combination of three-dimensional visualization, concept cards, environmental problem cards, and collaborative activities may have helped students understand ecosystem concepts more clearly. This finding is consistent with previous studies showing that Smart Box media can improve students' participation and science-learning outcomes by presenting learning materials in visual and interactive forms (Saofah et al., 2024; Utami et al., 2025). Aini et al. (2025) similarly reported that interactive Smart Box media could support students' learning potential by encouraging direct engagement with instructional content.

The present findings also suggest that the medium supported more than factual recognition. During the learning activities, students were required to identify ecosystem components, analyze food chains, discuss environmental problems, and explain ecosystem balance. These activities provided opportunities to connect factual information with relationships among concepts. Such opportunities are important because difficulties in ecosystem learning often arise when students can identify individual components but cannot explain their interactions within an ecological system (Kuroru & Rahmah, 2023; Sudianto & Rosyadi, 2024).

To determine whether the difference between the pretest and posttest scores was statistically significant, the data were analyzed using the Wilcoxon Signed-Rank Test.

Table 3. Results of the Wilcoxon Signed-Rank Test

Statistical Test	Significance (p)	Decision
Wilcoxon Signed-Rank Test	0.012	Significant ((p < 0.05))

The Wilcoxon Signed-Rank Test revealed a statistically significant difference between the students' pretest and posttest scores ((p=0.012)). In addition, 23 of the 32 students obtained higher posttest scores after participating in the learning activities, whereas the remaining students showed little or no improvement.

The statistically significant difference indicates that students' conceptual understanding changed after the implementation of the developed medium. The result is consistent with Utami et al. (2025), who found that the use of Smart Box media in elementary science instruction was associated with improved student learning outcomes. It also supports the findings of Saofah et al. (2024), who emphasized that Smart Box media can promote student participation through interactive science-learning activities. However, the present study contributes a more specific focus on conceptual understanding of ecosystem relationships rather than general achievement or learning motivation.

The learning gains may be explained by the interaction of several product features. The three-dimensional model provided a concrete representation of the ecosystem, the concept cards helped students classify and organize information, and the environmental problem cards required them to apply their knowledge to contextual situations. Collaborative discussions also enabled students to articulate their ideas, compare interpretations, and revise their understanding. Together, these activities may have supported the development of more coherent conceptual relationships.

The variation in student outcomes may reflect differences in prior knowledge, learning readiness, motivation, reading ability, and students' adaptation to the newly introduced instructional medium. Classroom-related factors, including group dynamics,

the duration of the intervention, and differences in student participation, may also have influenced the results.

The relatively large posttest standard deviation supports this interpretation because it indicates that students responded differently to the intervention. Some students may have benefited substantially from the visual and collaborative activities, whereas others may have required additional guidance, longer exposure, or differentiated learning support. Therefore, although the findings indicate positive learning outcomes, the observed improvement cannot be attributed solely to the Harmoni Smart Box Learning Media.

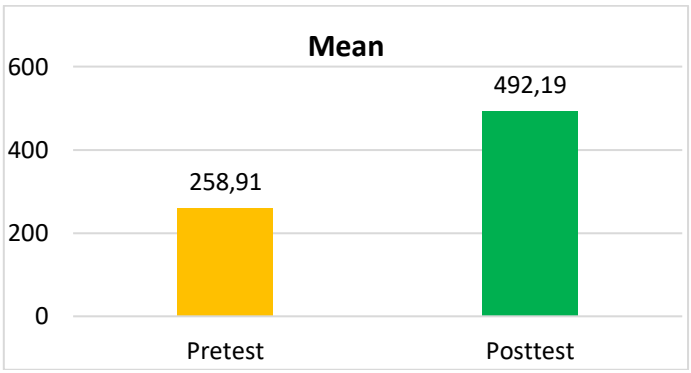

Figure 3. Comparison of mean pretest and posttest scores

The classroom implementation involved only one class at a single elementary school and did not include a control group. Consequently, the results should be interpreted as preliminary evidence from a limited product trial rather than conclusive evidence of instructional effectiveness. Other factors, including regular classroom instruction, repeated exposure to the assessment, and differences in students' individual characteristics, may have contributed to the observed changes.

Future studies should involve larger samples from multiple schools and employ experimental or quasi-experimental designs with appropriate control groups. Further research should also report effect sizes and examine learning gains across specific indicators of conceptual understanding, such as identifying ecosystem components, explaining food-web relationships, and analyzing ecosystem balance. Future versions of the Harmoni Smart Box Learning Media may incorporate digital components, such as QR codes or interactive applications, provided that these enhancements remain aligned with the intended learning objectives. The integration of digital resources may broaden access to ecosystem information, as digital learning materials have also been developed to support elementary students' understanding of ecosystem harmony (Qomara et al., 2024).

CONCLUSION

This study developed the Harmoni Smart Box Learning Media for teaching ecosystem concepts to fifth-grade students using the ADDIE model. The media integrates a three-dimensional ecosystem model, concept cards, environmental problem cards, Read Me cards, and student activity cards to support concrete, interactive, and student-centered learning. Expert validation confirmed that the media was highly feasible, while the limited field trial involving 32 students showed a statistically significant difference between pretest and posttest scores. These findings indicate that the Harmoni Smart Box has promising potential to support students' conceptual understanding. However, because the study involved only one class and did not include a control group, the results should be interpreted as preliminary. Future

studies should involve larger and more diverse samples and employ experimental or quasi-experimental designs.

RECOMMENDATION

Further research is recommended to develop the Smart Box Harmony in the Ecosystem for other science and science subjects so that the media's benefits can be applied more widely. Furthermore, research can be conducted involving a larger number of subjects and diverse school characteristics to obtain more comprehensive results. Media development can also be combined with digital technology, such as QR codes or interactive learning applications, to improve accessibility and student learning experiences. In its implementation, this study still has limitations, namely the limited number of subjects in one class and the relatively short implementation time. These factors can influence the research results and need to be considered in future research.

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