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Box Ocean Ecosystem Sorting Media (BOESM) Development based on Coding and Artificial Intelligence Unplugged

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Abstract

The development of coding and artificial intelligence (AI) learning in Indonesia faces the challenge of digital infrastructure inequality, especially in 3T (underdeveloped, frontier, outermost) areas. This study aims to design and test the Box Ocean Ecosystem Sorting Media (BOESM) learning media, an unplugged media that teaches programming logic and AI concepts through marine ecosystem concept classification activities. The study employs a 4D development model (Define, Design, Develop, Disseminate) involving elementary school teachers and students who lack adequate access to digital devices. Data collection techniques include field observation, interviews, questionnaires, expert validation, and analysis of pretests and posttests. BOESM utilizes concrete objects to simulate algorithmic thinking patterns (IF-THEN logic) by grouping marine components, including fish, sand, and plastic waste. The results of expert validation showed that the media was very feasible, and the field trial produced a moderate gain score (0.52), indicating an increase in students' understanding of computational thinking. As many as 92% of students reported enjoying learning without the use of digital devices. The study concluded that BOESM is effective in fostering algorithmic thinking and early AI literacy in technologically constrained environments and is an inclusive and cost-effective learning alternative.

Keywords: Artificial Intelligence, Computational thinking, Marine ecosystem concept, Programming logic, Unplugged learning.

INTRODUCTION

The development of digital technology and artificial intelligence (AI) has penetrated almost all aspects of life, including the world of education (Ma et al., 2023). The national curriculum has also begun to respond to this dynamic by incorporating coding and Artificial Intelligence materials as an essential part of 21st-century competencies(Sasmita et al., 2021). However, not all educational units have adequate access to digital infrastructure, including stable internet networks, computer devices, and trained educators (Li et al., 2022). This creates a digital mindset gap between students in schools with comprehensive facilities and those in schools with limited facilities(Karnadi et al., 2021).

The lag in the digital mindset is not only related to the lack of technical skills in using technology but also to limitations in understanding how digital technology works and thinking algorithmically. Without this understanding, students will struggle to adapt to the industrial era 4.0 and 5.0, which demands digital literacy as a fundamental skill (Yatimah et al., 2018). Therefore, an educational solution is needed that can bridge the gap between digital learning and real-world conditions, especially for schools in disadvantaged, outermost, and frontier areas (3T) (Solihin, Bae, et al., 2025).

One approach that can be used to overcome infrastructure limitations is the development of unplugged-based learning media, a method of teaching coding and KA concepts that does not require digital devices.(Solihin, Apriliani, et al., 2025). This approach emphasizes physical activities, role-playing, simulations, and simple manipulatives that can represent programming logic and basic KA principles. In addition to being cost-effective, the unplugged method also encourages active and participatory learning and can be easily adapted by teachers from various backgrounds. Through the development of unplugged media, students can still gain a basic understanding of how technology works without having to wait for the availability of digital devices.(S & Dedah, 2022). Thus, this media is not only an alternative solution but also an inclusive and transformative pedagogical strategy in minimizing the digital divide. Therefore, this article aims to explore and develop practical and contextual forms of unplugged media in teaching Coding and Artificial Intelligence in schools with limited digital infrastructure(Yusuf et al., 2024).

RESEARCH METHODS

This study uses a Research and Development (R&D) approach. The 4D development research model (Four-D Model) was developed by Thiagarajan, Semmel, and Semmel in 1974. This model is widely used in the development of learning devices or learning media. This

model consists of four main stages: Define (Definition), Design (Design), Develop (Development), and Disseminate (Dissemination). This type of research is development research, aiming to produce unplugged learning media that can be used to teach Coding and Artificial Intelligence material in a contextual context without the need for digital devices, focusing on the concept of marine ecosystems to replace the KKA AI for Oceans media.(Hartopo et al., 2023).

The subjects of the study were teachers and students in elementary schools located in areas with limited digital infrastructure, particularly schools that lacked computer laboratories or stable internet connections and were using unplugged media types. Unplugged learning is a learning method that eschews the use of digital devices, yet it still teaches fundamental computer science concepts, including algorithmic logic, problem-solving, and computational thinking. This method is suitable for use in schools with limited technology(Kim, 2022). Data collection was carried out using various techniques, including Field observations to identify real conditions in schools, Interviews with teachers and principals regarding needs and obstacles in learning coding and KA, Questionnaires to determine students' understanding of digital mindsets and basic algorithm concepts, Expert validation (media and materials) to assess the feasibility of the unplugged media design developed, Learning outcome tests to determine the increase in students' understanding of concepts. The instruments used include observation sheets, interview guides, needs questionnaires, expert validation sheets (based on the Likert scale), and HOTs-based cognitive test questions (C1–C4) on the basics of coding and KA, as well as the concept of marine ecosystems. Qualitative data were analyzed using qualitative descriptive techniques. In contrast, quantitative data were analyzed using the percentage of media feasibility from expert validation results, Gain score analysis to measure the increase in student learning outcomes before and after using the media, and Analysis of student responses to understanding and involvement in the learning process using unplugged media (Munasinghe, 2023).

RESULTS AND DISCUSSION

Ocean Ecosystem Sorting Media Box Concept and its Relationship with Coding and KA (Artificial Intelligence) Concept. A sorting box is a physical medium used to teach how to group objects based on specific rules. In the context of the marine ecosystem, this box can be used to distinguish between Living Organisms (fish, seaweed, coral reefs), Non-living Components (seawater, sand), and Pollutants or waste (plastics, metals, bottles, nets). Even without a computer, this sorting box media can introduce students to decision-making

algorithms that are the basis of computer logic and KA. For example, If the object can breathe, then put it in the living creature category. If the object floats and is not part of the ecosystem, categorize it as marine debris. This logical structure is similar to the branching (IF-THEN) in the algorithm.

Learning Steps for Unplugged Media: Box Ocean Ecosystem Sorting.

Here is a table of learning steps for the Unplugged Media Box: Ocean Ecosystem Sorting.

Table 1. Learning Steps for Media Box Ocean Ecosystem Sorting

Steps	Activity
1. Orientation	Teachers explain the condition of marine ecosystems and the problems associated with pollution.
2. Observation	Students observe replicas, miniatures, or pictures of various marine objects.
3. Classification	Students place objects into category boxes labelled "Fish," "Trash," or "Natural Components."
4. Logical reflection	Students explain why an object is put into a particular category.
5. Generalization	Students compose "classification rules" such as IF-THEN verbally or in writing.
6. Reinforcement of concepts	The teacher explains that this is the initial form of programming logic and how Artificial Intelligence works in recognizing objects.

Unplugged learning does not require electricity, internet, or computers and can be made from recycled cardboard, printed images, or concrete objects such as shells, plastic pieces, and toy fish. This makes it economical, contextual, and sustainable.

Expert Validation Results

Validation was conducted by two material experts (biology and informatics) and two media experts. The assessment results are shown in the following table:

Table 2. Validation of Media Box Ocean Ecosystem Sorting

Assessment Aspects	Average Category	Score
Suitability of Material to Curriculum	4,6	Very Worthy
Clarity of Algorithm Flow in Media	4,4	Worthy
Readability and Aesthetics of Media	4,2	Worthy
Ease of Implementation in Low-Tech Schools	4,8	Very Worthy

Limited Trial Results

The trial was conducted in one of the schools in the Sukabumi area with 25 students of grade V. The test was performed before and after the use of the media. The results of the pretest-posttest were analyzed with Gain Score as follows:

Table 3. Gain Score for Box Ocean Ecosystem Sorting media

Average pretest score	Average posttest	score Gain Score
51,2	76,4	0,52 (moderate category)

As for the Student and Teacher Responses regarding the Box Ocean Ecosystem Sorting media, 92% of students stated that they enjoyed learning without computers but still liked playing logic, 88% of students were able to understand how classification works through the determining box activity, and 84% of 15 Teachers stated that this media is easy to apply and by field needs, and can simplify the concept of initial programming without digital tools.

Table 4. Relation to Computational Thinking Elements (KKA)

KKA Elements	**Activity Description on Media**	**Impact on Students**
Decomposition	Students break down complex problems (marine ecosystems) into smaller units (types of objects)	Facilitates understanding and mapping of work logic
Pattern Recognition	Students recognize patterns: living things → breathing, trash → man-made	Accelerates feature-based decision making
Abstraction	Ignore irrelevant information (such as color and size) and focus on the essential features for classification.	Train focuses on essential features in data processing.
Algorithm Design	Organize logical sequences: identification → decision → classification	Form systematic thought processes, like in coding
Debugging / Evaluation	Correct classification errors through group discussion or reflection	Encourage logical evaluation and independent correction

Table 6. Analysis of the Performance of Marine Ecosystem Determinant Box Media: Relation to Programming Language and Computational Thinking

No	**Student Activities Using Media**	**Represented Programming Language Components**	**Computational Thinking Elements Developed**
1	Classifying objects (fish, trash, reefs, etc.)	IF–THEN statement	Decomposition (breaking objects into categories)
2	Determining logic: "if an object is alive, then..."	Conditional logic (branching logic)	Logical reasoning

3	Sequencing the process: observation → classification → reason	Algorithmic sequencing	Algorithm design
4	Finding characteristics of visual data	Pattern recognition	Pattern recognition
5	Discussing differences in classification	—	Abstraction (understanding the essence of each category)
6	Explaining classification decisions to friends	—	Debugging (correcting classification logic)

Discussion

The Ocean Ecosystem Sorting Box media developed in this study has proven to be effective in introducing algorithmic patterns, even in schools without ICT facilities. This aligns with the concept of computational thinking, which can be taught through physical and manipulative activities (Wing, 2006). Through this medium, students are invited to think in the IF-THEN-ELSE framework, a fundamental structure in programming languages. The selection of the marine ecosystem theme provides two double benefits: 1). Students understand the importance of protecting the marine environment from pollution; 2). They also learn how to classify objects based on characteristics — an essential principle in machine learning and artificial intelligence. This demonstrates cross-disciplinary integration that aligns with the Deep Learning approach (Tsortanidou, 2022). The increase in pretest to posttest scores indicates an increase in students' understanding of systematic and logical thinking patterns. This suggests that unplugged learning is no less effective than the digital-first approach, as long as the media design is relevant and contextually relevant. The use of physical box media makes students more active motorically and socially, practicing problem solving in groups. This encourages the creation of meaningful learning, as stated by Ausubel. Although this media shows positive results, limitations arise in the aspect of standardization of classification logic between students, who sometimes have different points of view. Therefore, future development can involve a more explicit basic logic reinforcement module before students use this media(Kim, 2022).

Box Ocean Ecosytem Sorting is an unplugged learning tool designed to resemble a simple automatic classification system. This media consists of a box with three main compartments/categories, Marine Creatures (fish, coral reefs, seaweed), Abiotic Components (seawater, sand), and Marine Debris/Pollutants (plastic, nets, bottles). Students are given objects/miniature images (in the form of cards), and they are asked to classify the objects into the appropriate category based on certain rules. Although done without a computer, the

activities in Box Ocean Ecosystem Sorting teach basic programming structures, especially branching logic (conditional logic), namely: IF the object breathes or grows, THEN group it as a living thing. ELSE IF the object is not a living thing and comes from nature, THEN abiotic. ELSE → marine debris. This activity is an analogous form of the if-else command in programming. Students indirectly train their ability to compile algorithms, think logically, and develop data processing sequences(Dai, 2024).

Box Ocean Ecosystem Sorting can also be interpreted as an early representation of the Artificial Intelligence process, especially in classification-based machine learning. In the AI system: Data = objects (images of living things, abiotic, and waste), Labels = categories (living, abiotic, waste), Classification algorithms = feature-based classification rules (e.g., "breathing," "natural," or "man-made"). By getting students used to identifying objects and grouping them based on characteristics, they are introduced to the concept of data training and supervised learning, where AI learns from similar grouping patterns(Pyun, 2025).

Box Ocean Ecosystem Sorting facilitates the strengthening of several elements of KKA (Computational Thinking). Among these, active and meaningful learning, this approach is also aligned with active and constructivist learning, where students are physically and cognitively engaged, collaborating to solve classification problems and learning from mistakes in the process of "debugging" classification(Song, 2021). This method fosters an inclusive, fun, and problem-based learning atmosphere while conveying the essence of programming logic and KA, all without the use of digital devices. Box Ocean Ecosystem Sorting is also very flexible. It can be developed into an ecosystem-based unplugged KA learning module, applied to other themes (such as rainforests and rivers), connected to digital literacy and environmental narratives, and used in digital mindset strengthening training in 3T schools due to the Effectiveness of Unplugged Media in Growing Computational Thinking. Recent meta-analyses have demonstrated that unplugged activities—such as board games and card-based exercises—significantly enhance students' computational thinking skills, particularly in aspects related to algorithms, branching, and debugging (Huang & Looi, 2020). Box Ocean Ecosystem Sorting represents the direct practice of IF–ELSE–THEN and algorithmic sequencing. Hence, the gain score result of 0.52 (moderate level) is consistent with the effectiveness of similar methods in other studies.(Li et al., 2022).

The IF–ELSE–ELSEIF mechanism in the specifying box replicates the fundamental branching logic structure in programming. According to Wing, (2006) Definition: Computational thinking is “the process of constructing solutions to problems that information-

processing agents can execute." Students who systematically classify objects in this medium are indirectly constructing computational steps—the basic steps in writing code.

Box Ocean Ecosystem Sorting simulates the process of supervised learning in AI: students confirm object features, assign labels, and apply rules for classification. This media involves using a model that learns from data (training) and predicts labels. This AI literacy is essential today, especially for students in areas with limited access to technology. Hour of Code studies highlight the importance of striking a balance between theory and hands-on learning in AI literacy education. Box Ocean Ecosystem Sorting reinforces several elements of computational thinking, where students can break down the ocean ecosystem into smaller categories (living, abiotic, and debris). Pattern Recognition: Where students can identify features such as respiration or artificial materials. Abstraction: Where students can filter out irrelevant features, such as color and size. Algorithm Design, where students can compile classification steps. Furthermore, debugging, where students make corrections and engage in discussions when errors occur in category placement. Unplugged activities, which incorporate a game-based and socialization approach, have been shown to increase student motivation and engagement (Ma et al., 2023). This response is reflected in student responses (92% enjoy learning) and the smooth implementation in the field, which is compatible with the principles of gamification and active learning.

RESEARCH LIMITATIONS

This study reveals potential bias in students' varying understandings of logic. The literature suggests that media should be accompanied by explicit reflection and debugging modules to strengthen CT. Additionally, further development can include incorporating more complex levels or utilizing lightweight digital media to facilitate the transition to real coding.

CONCLUSION

The unplugged-based decision box is a simple yet meaningful innovation that not only teaches marine ecosystem science but also instills logical digital thinking. With this approach, technological limitations are no longer a barrier to developing coding and AI literacy from an early age.

REFERENCES

Dai, Y. (2024). Integrating unplugged and plugged activities for holistic AI education: An embodied constructionist pedagogical approach. *Education and Information*

Technologies, *30*(5), 6741–6764. https://doi.org/10.1007/s10639-024-13043-w

Hartopo, I., Zakarijah, M., & Aliyavi, A. (2023). The Effectiveness of Robot Learning Media to Support Self- Directed Learning during the Covid-19 Pandemic. *Journal of Education Technology*, *7*(2), 315–322.

Huang, W., & Looi, C. K. (2020). A critical review of literature on "unplugged" pedagogies in K-12 computer science and computational thinking education. *Computer Science Education*, *31*(1), 1–29. https://doi.org/10.1080/08993408.2020.1789411

Karnadi, K., Sasmita, K., Badrudin, B., Palenewen, E., & Solihin, S. (2021). Diamond Touch (DT) based on hyperactive game in applying the concept of life science in early childhood education Diamond Touch (DT) based on hyperactive game in applying the concept of life science in early childhood education. *Journal of Physics: Conference Series*, *1760*(012014), 1–5. https://doi.org/10.1088/1742-6596/1760/1/012014

Kim, S. (2022). 언플러그드 활동을 중심으로 Development and Application of Artificial Intelligence Convergence Education Program Based on Decision Tree : Focusing on Unplugged Activities. *Journal of Practical Engineering Education*, *14*(January), 459–469.

Li, F., Wang, X., He, X., Cheng, L., & Wang, Y. (2022). The Effectiveness of Teaching Approaches in Computational Thinking Education: A Meta-Analysis. *ACM International Conference Proceeding Series*, 386–392. https://doi.org/10.1145/3572549.3572611

Ma, R., Sanusi, I. T., Mahipal, V., Gonzales, J. E., & Martin, F. G. (2023). Developing Machine Learning Algorithm Literacy with Novel Plugged and Unplugged Approaches. *SIGCSE 2023 - Proceedings of the 54th ACM Technical Symposium on Computer Science Education*, *1*, 298–304. https://doi.org/10.1145/3545945.3569772

Munasinghe, B. (2023). Programming unplugged: insights from theoretical models and teacher experiences. *Programming Unplugged: Insights from Theoretical Models and Teacher Experiences.*

Pyun, Y.-S. (2025). 유아교육에서 소프트웨어와 인공지능 역량 교육 강화 전략 - 언플러그드교육활동과 플러그드 교육활동 중심- Strategies for Enhancing Software and Artificial Intelligence Competencies in Early Childhood Education. *사물인터넷융복합논문지 Vol.*, *11*(2), 35–44.

Solihin., & Dedah. (2022). Analisis Intention to act dan Motivasi Belajar Siswa Pasca praktikum Isolasi DNA Sederhana Menggunakan Alat dan Bahan Dapur. *Biosfer : Jurnal Biologi Dan Pendidikan Biologi*, *7*(2). https://doi.org/10.23969/biosfer.v7i2.6531

Sasmita, K., Palenewen, E., K Karnadi, S. S., & Badrudin, A. (2021). *What ' s App integrity in the life science concept during the covid-19 pandemic What ' s App integrity in the life science concept during the covid-19 pandemic*. https://doi.org/10.1088/1742-6596/1760/1/012028

Solihin, Apriliani, A. S. N., & Jannah, A. N. N. (2025). ROCED: Robot card biology education as a media for biology learning Solihin. *JPBIO (Jurnal Pendidikan Biologi)*, *10*(1), 35–49. https://doi.org/https://doi.org/10.31932/jpbio.v10i1.4227

Solihin, Bae, K., Nuraini, E., & Purwanto. (2025). Media CARCO (Card Ecology) dalam Pembelajaran IPAS pada Konsep Ekologi Lingkungan di Kelas X SMK Islam Al-Qudsyiah. *BIOSFER, J.Bio. & Pend.Bio*, *10*(1).

Song, J. (2021). Development and Validation of Artificial Intelligence Education on the Environmental Education Based on Unplugged. *Journal of The Korean Association of Information Education*, *25*(5), 847–857. https://doi.org/10.14352/jkaie.2021.25.5.847

Tsortanidou, X. (2022). *Developing social-emotional, new media literacy and computational thinking skills through unplugged approach and imagination-based pedagogies in primary ….* 1–87. https://openaccess.uoc.edu/handle/10609/145129%0Ahttps://openaccess.uoc.edu/bitstream/10609/145129/1/Doctoral Thesis_Xanthippi Tsortanidou-final.pdf

Wing, J. M. (2006). Explanation-based learning. *Computer Science Handbook, Second Edition*, *49*(3), 68-1-68–18. https://doi.org/10.1201/b16812-43

Yatimah, D., Puspitaningrum, R., S, S., & Adman. (2018). Development of Instructional Media Environmental-based Child Blood Type Detector Cardboard (KAPODA) Formal and Informal Education Development of Instructional Media Environmental-based Child Blood Type Detector Cardboard (KAPODA) Formal and Informal E. *IOP Publishing*, *434*(012236), 1–6. https://doi.org/10.1088/1757-899X/434/1/012236

Yusuf, Azizah, N. L., Suci, T. P., & Walida, S. El. (2024). Implementasi Pembelajaran Berbasis Artificial Intelligence Melalui Media Canva Pada Calon Guru Matematika. *Jurnal Pengabdian Kepada Masyarakat Bersinergi Inovatif*, *1*(2), 101–108. https://doi.org/10.61674/jpkmbi.v1i2.154