

Developing a Sustainable Design-Based Creative Board Game to Enhance Children's Creativity and Maritime Awareness

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(Received January 19, 2026; Revised April 25, 2026; Accepted April 25, 2026)

Abstract

Creativity is an important 21st century competency in which instructional media must be able to stimulate flexible thinking and meaningful problem solving. Board games offer significant pedagogical potential by integrating playfulness with structured cognition. However, most of the commercial board games still use plastic-based materials, which raises concern about the environmental sustainability, especially in the context that is affected by plastic pollution. To address this gap, the present study developed a creative board game with a maritime environmental awareness theme using the Design for Sustainability (DfS) approach, ensuring dual pedagogical value that fostering children's creativity while embedding ecological responsibility through sustainable material and design. The Research and Development (R&D) method following the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) stages of the ADDIE model. Validation results showed feasibility scores of 89%, based on media experts, and 88%, based on material experts, which are both in the "highly feasible" category. These findings validate the board game as a sound medium for stimulating creativity and ecological awareness. Future research should implement and evaluate the tool with children to provide empirical evidence of its effectiveness.

Keywords: children's creativity, creative board game, design for sustainability, maritime environment

How to Cite:

Juniani, A. I., Amelia, P., Widiana, D. R., Wiediartini, W., Primaningtyas, W. E., Amin, K., Indrawan., R., Maulana, R. A., Santosa, R. B., Anjhani, D. A. J., & Kurniawan, D. K. (2026). Developing a sustainable design-based creative board game to enhance children's creativity and maritime awareness. *Journal of Innovation and Community Engagement*, 7(2), 137-155.
<https://doi.org/10.28932/ice.v7i2.14425>

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Introduction

Creativity is increasingly recognized as a fundamental skill for students navigating the demands of the 21st century, particularly amid accelerated technological and social transformation that requires students to think flexibly and engage in complex problem-solving. Major international policy frameworks converge on this view: the World Economic Forum (2023) highlights creativity, critical thinking, and complex problem-solving as key future skills, while UNESCO (2015) and the OECD (2019) place creativity at the core of contemporary skills-based education frameworks. Despite this strong policy discourse, UNICEF (2023) estimates that nearly 70% of children in the Asia-Pacific region still do not experience learning activities that systematically nurture creativity and higher-order thinking, indicating a substantial gap between normative expectations and classroom practice.

To adequately conceptualize the construct being developed, creativity in the present study is understood through the lens of Torrance's (1966) seminal framework, which identifies four key dimensions, fluency (the ability to generate multiple ideas), flexibility (the capacity to shift between different categories of thinking), originality (the production of novel and unexpected responses), and elaboration (the ability to develop and enrich ideas with detail). This multidimensional framework provides the theoretical basis for the activity card design and assessment criteria embedded in the board game, ensuring that the learning product targets specific and measurable creative competencies rather than creativity as an undifferentiated capacity.

Board game-based learning represents a well-established approach to bridging this pedagogical gap. Games that incorporate structured rules, progressive challenges, and narrative contexts that encourage children to experiment, collaborate, and problem solving within a safe and engaging environment, and solve problems in a safe setting. This method encourages both active thinking and positive social interaction. Empirical research indicates that board games promote multidomain learning, including the development of critical thinking, collaboration, and the acquisition of domain-specific knowledge (Alotaibi, 2024; O'Neill & Holmes, 2022; Armenia et al., 2024). These features are especially important for kids in late primary school because they combine fun with structured tasks that can help them meet their learning goals.

However, the proliferation of commercial board games has raised environmental concerns. Most commercial products are still manufactured using plastic-based materials, which contribute to the accumulation of plastic and microplastics in aquatic environments. Studies by Arboleya Garcia and Miralles (2022) and Vecchio and Greco (2023) highlight the fact that such materials will end up in the marine environment and contribute to ocean pollution. This problem is particularly acute in Indonesia, where it has been estimated from LIPI and the Ministry of Marine Affairs and Fisheries (2022) that over 0.52 million tons of plastic get into the sea annually. In this context, board games for education that are based on conventional plastic parts run the risk of sending mixed messages if they are used to teach environmental responsibility.

These conditions suggest a dual challenge: the need for learning media that truly support children's creativity, and at the same time reflect principles of sustainability of the environment. While existing research documents positive effects of games and board games on environmental literacy and pro-environmental behavior (Chen & Ho, 2022; Dela Cruz et al., 2024; Priskadana Putra & Mansoor, 2023), systematic attempts to integrate sustainability principles into the design of creative board games for children remain limited. More specifically, no prior study has been identified that combines: (1) a DfS-driven material selection framework, (2) creativity-stimulating game mechanics grounded in established theoretical models, and (3) thematically coherent maritime environmental content, within a single learning product targeted at primary school-aged children. This triple integration constitutes the core novelty of the present study.

This study fills a gap by developing a creative board game incorporating the DfS approach that teaches children about maritime environmental issues. As articulated by Crul and Diehl (2009) and further elaborated by Vezzoli et al. (2018), DfS is a strategic design methodology that integrates environmental, social, and economic sustainability criteria throughout the entire product development lifecycle from material selection and production processes to end-of-life considerations. In the context of this study, DfS operationalization entails the exclusive use of non-toxic, recyclable and biodegradable materials (cardboard, origami paper, and plasticine), and the deliberate weaving of sustainability values into the game's mechanics and narrative structure. This lets children learn about ecology while playing. This method aligns with broader efforts to encourage environmental responsibility from an early age (Putri et al., 2024).

Beyond individual creativity and environmental awareness, the thematic focus on maritime ecosystems holds particular relevance for Indonesia as an archipelagic nation comprising over 17,000 islands and whose economic and cultural identity is deeply intertwined with the sea. The UNESCO-IOC Ocean Literacy Framework (2012) defines ocean literacy as an understanding of the ocean's influence on human life and its essential role in Earth's systems. Integrating ocean literacy principles into early childhood and primary education has been identified as a critical leverage point for cultivating long-term pro-environmental attitudes and behaviors toward marine conservation (Fortuin & van Koppen, 2016; Surma et al., 2021). The present board game is thus conceived not only as a tool for generic environmental education but as a contextually grounded maritime education instrument.

Research indicates that sustainability-themed board games can influence attitudes and knowledge. For instance, Chen and Ho (2022) reported that a board game based on United Nations Sustainable Development Goals enhanced players' understanding of environmental issues. Similarly, Putri et al. (2024) observed that a conservation-themed game increased children's ecological knowledge and promoted pro-environmental behaviour. Furthermore, Agustin and Aji (2023) and Arboleya Garcia and Miralles (2022) demonstrated that well-designed games foster critical thinking and environmental literacy through targeted game mechanics. Building on these insights, this study will create a sustainable, maritime-themed board game to cultivate creativity and marine environmental awareness among children.

Building on these foundations, the present study is guided by the following research question: How can a sustainable design-based creative board game be developed and validated as a feasible learning medium to enhance children's creativity and maritime environmental awareness? Specifically, this study aims to: (1) develop a prototype board game integrating DfS principles and maritime environmental content; and (2) assess the feasibility of the prototype through expert validation in terms of media quality and material quality.

Methods

This study used the research and development approach in terms of the main objective, which was to create a tangible learning product in the form of a creative board game and to record the development procedures and feasibility evaluation in a systematic way. Following the practices

commonly used in educational technology's research and development work (Purnama, 2016; Sugiyono, 2008), the study's importance was the iterative improvement of the product based on empirical inputs and expert judgment.

The development process followed the ADDIE instructional design model (Branch, 2009) and was deliberately restricted to the first three stages of the process: Analysis, Design, and Development (ADD). This scope was chosen as phase one with the goal of creating a validated prototype before user trials. The ADDIE model was selected owing to its systematic yet flexible model, where the outputs of each stage become the input of the next one, supporting a coherent and goal-oriented learning design (Cahyadi, 2019). This study explicitly positions the ADD phases as a prototype development cycle, with the Implementation and Evaluation stages reserved for future research involving end-user children in school settings. This demarcation is consistent with practice in preliminary R&D studies and is clearly acknowledged as a methodological boundary rather than a shortcoming.

The two partner institutions that served as community partners in this study were Asrama Sahabat Yatim Klampis orphanage and Permata Insani Foundation, both located in Surabaya, East Java, Indonesia. These institutions provided the primary site for needs analysis and contextual data collection. The target learners were children aged 9–10 years ($n \approx 20$ across both sites), selected purposively based on their developmental stage, which corresponds to the late concrete operational phase in Piaget's cognitive developmental theory, a stage at which children are particularly responsive to visual, kinesthetic, and problem-based learning stimuli. The orphanage caregivers and institutional administrators served as key informants during the structured interviews conducted in the analysis phase. The partner institutions' contributions were principally at the level of providing contextual access, needs data, and environmental observations, rather than co-design or prototype evaluation. Figure 1 demonstrates the conceptual framework of the creative board game development process according to the ADD stages.

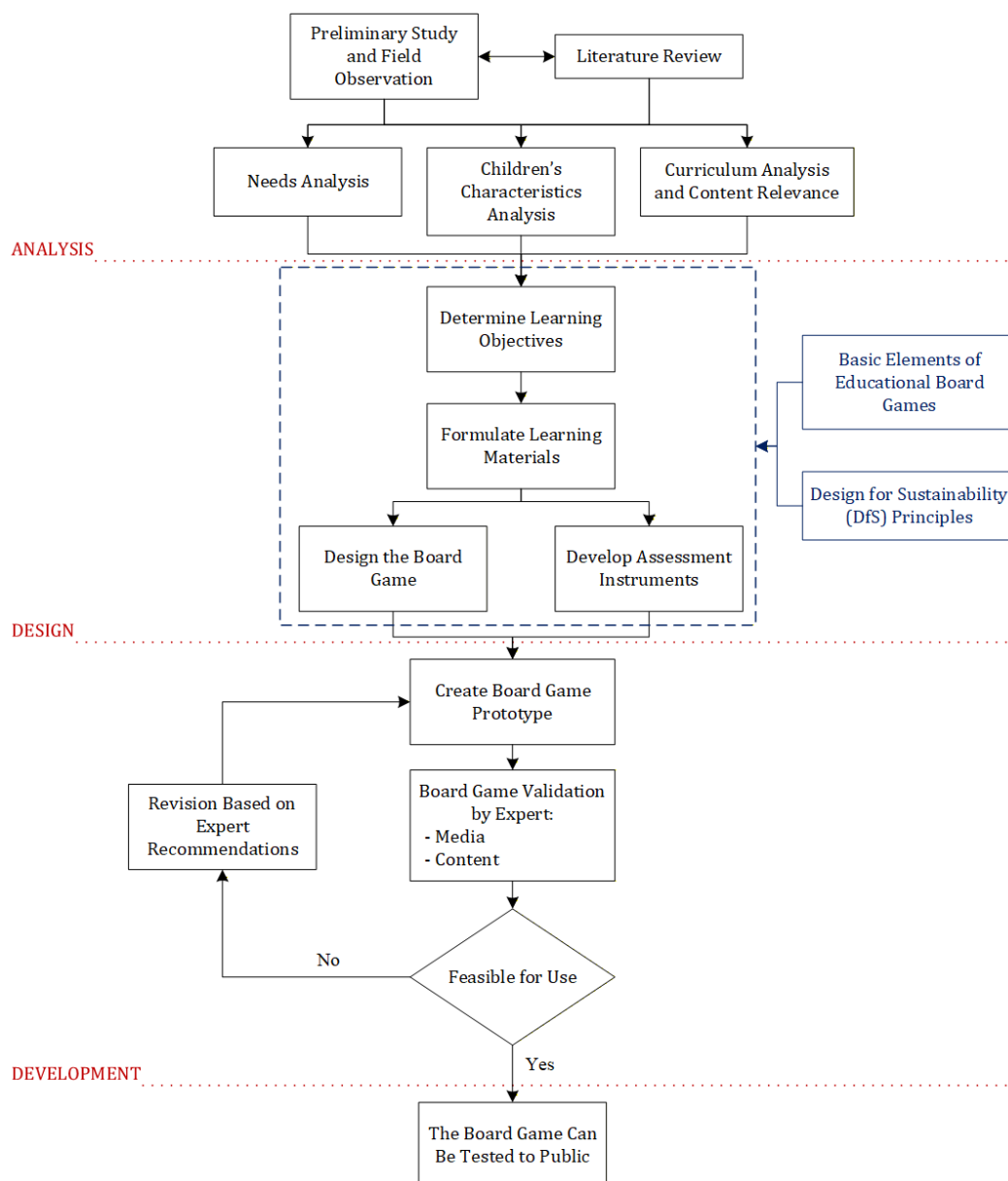


Fig 1. Conceptual framework for creative board game development

The analysis stage was performed to identify the basic requirements for the development of a creative board game aimed at developing creativity and maritime environmental awareness by means of structured play activities, while at the same time being consistent with the characteristics of the learner and the educational context. Data were obtained from the field observations and structured interviews conducted in Asrama Sahabat Yatim Klampis orphanage and Permata Insani Foundation in Surabaya, and the literature review about educational board games, creativity development, and environmental education. The information gathered was synthesized in terms of needs analysis, learner characteristics

analysis, and the analysis of curriculum and content relevance to lead to the formulation of learning objectives and content selection.

The design stage was focused on taking the outputs of the analysis stage and turning them into a structured product blueprint, encompassing learning objectives, thematic content organization, game mechanics, and component specifications (board layout, activity cards, rules). DfS principles were operationalized through the selection of recyclable, non-toxic, and biodegradable materials. Visual and aesthetic elements were designed to align with the maritime theme and the visual preferences of the target age group. Simultaneously, validation instruments were constructed to assess both media quality (visual design, component usability, thematic coherence) and material quality (content accuracy, alignment with learning objectives, language accessibility, and age-appropriateness).

The development stage meant creating a physical prototype of the board game according to the design specifications already established, then validation by experts, and then revising it and iterating. Expert validation was conducted by two qualified practitioners. The media expert holds a postgraduate qualification in educational technology and has a minimum of five years of experience in the design and evaluation of game-based learning media, including board game development for primary education. The material expert is a practitioner-educator with expertise in environmental and sustainability education at the elementary school level, with documented experience in curriculum development and instructional materials assessment for the target age group. Both validators were selected based on predetermined qualification criteria to ensure the credibility and relevance of the validation feedback. Validation data were collected using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), as presented in Table 1.

Table 1. Assessment criteria by validator

Score	Criteria
5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

Quantitative data from expert assessments were analyzed using descriptive statistics as the percentage of validation scores on Equation (1), which is a comparison of the total empirical score obtained with the ideal total score (Khotimah & Wahyuningtyas, 2023).

$$V_a = \frac{T_e}{T_i} \times 100\%$$

Information:

V_a = expert validation value

T_e = total empirical score obtained

T_i = ideal total score

The resulting percentages were then interpreted in conjunction with product eligibility criteria, which are shown in Table 2, to determine the level of feasibility of the developed board game. Qualitative feedback in the form of comments and suggestions from the experts was analysed and used to guide iterative revisions of the prototype until the predefined feasibility criteria were reached.

Table 2. Product eligibility percentage criteria

No.	Validation Achievement Level (%)	Criteria	Explanation
1	75.01 – 100.00	Highly appropriate	Can be used without revision
2	50.01 – 75.00	Moderately appropriate	Can be used with minor revisions
3	25.01 – 50.00	Less appropriate	Can be used with major revisions
4	01.00 – 25.00	Not appropriate	Can not be used

Source: (Khotimah & Wahyuningtyas, 2023)

Results and Discussions

The creative board game was developed over approximately 3 months, from August to October 2025, at the Asrama Sahabat Yatim Klampis orphanage and the Permata Insani Foundation in Surabaya. Both partner institutions contributed to the research primarily at the analysis stage, providing contextual access for observation and interview-based data collection. Caregivers and institutional administrators at both sites participated in structured interviews that yielded key insights into existing learning practices, children's developmental characteristics, and the educational needs of the target population. These contextual inputs directly informed the subsequent design and development decisions, ensuring that the resulting prototype is grounded in the empirical realities of the communities it is intended to serve.

Analysis Stage

The analysis stage revealed key needs and contextual conditions related to existing learning practices. Observations in the classroom and interviews with caregivers revealed that learning was still very dependent on traditional media such as printed modules and student worksheets, on teacher-centered delivery, and on few opportunities for the children to explore or be creative. In such circumstances, children may appear passive and unable to concentrate, especially during longer teaching sessions.

These findings indicate the need for a more contextual, experiential, and activity-based learning approach that allows children to actively engage, explore, and construct meaning through play. In response to this need, environmental and maritime awareness was selected as the major theme, as it provides rich, concrete, and locally relevant contexts that can stimulate exploration while fostering ecological awareness at an early age. The theme was also aligned with the Pancasila Student Profile, focusing on the virtues of virtuous character, mutual cooperation, and creativity as values to be developed throughout the game. The learner characteristics were analyzed to support the assumption that children aged 9-10 years in both orphanages were likely to respond positively to visual and kinesthetic stimuli, thereby justifying the decision to design a board game incorporating visual features, physical activities, and hand-based activities.

It is important to note that the children at both partner institutions participated in this study in the role of primary beneficiaries of the community engagement activity, insofar as the board game was developed specifically to address their identified learning needs. Their characteristics and contextual circumstances shaped every design decision made throughout the development process. The community being served, therefore, is the children population at these orphanage settings, a group that represents an underserved segment of society with limited access to quality, creativity-stimulating learning media.

Design Stage

In the design phase, the analysis findings were converted into articulated learning objectives, designed materials, and elaborated game elements. Learning objectives were designed to raise children's awareness of the need to conserve the marine environment and to encourage creative thinking through goal-oriented challenges, but in a playful manner. It was structured around

three key points: introducing the children to marine ecosystems, the effects of plastic waste on marine life, and basic actions the children can take to help keep oceans clean. These resources were then incorporated into the game components through the board layout, rules, and activity cards. These objectives were operationalized in alignment with Torrance's (1966) creativity dimensions, with origami tasks targeting elaboration and fluency, plasticine modeling fostering originality and flexibility, and storytelling activities stimulating fluency and elaboration through narrative construction. The game mechanics were thus designed not merely as entertaining challenges, but as structured pedagogical interventions targeting specific creative competencies.

The principles of DfS were realized through the choice of environmentally friendly materials and logical visual identity. Cardboard, origami paper, and plasticine were used to design the board and supporting components, and images of fish, coral reefs, and ships were used to reinforce the maritime theme. Eight primary colours were selected as a colour palette (navy blue (026abe), green (4a9001), cream (f8d494), red (ce2817), brown (915516), light blue (86ccdf), dark blue (16335d), yellow (fdd422) to be used to make the atmosphere cheerful and reflecting the sea but to make sure that the color palette is appealing to children. Figure 2 shows the colour branding of the creative board game, and Figure 3 shows the general look of the board game prototype.

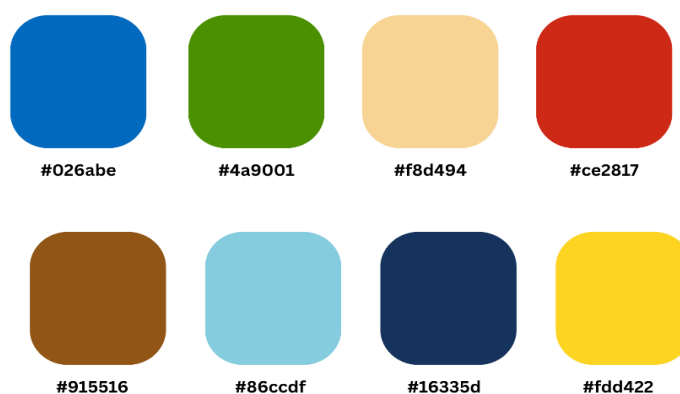


Fig. 2. Color branding creative board game



Fig. 3. Display creative board game

The game components consisted of a main board, pawns, a die, and nine activity cards divided into four categories: origami, plasticine, storytelling, and reward cards. The game has been created to be played between two or four players, and the game is based on turn-taking. Pawns are moved, depending on the roll of the die, and then the directive on the square which a player lands on; a successful challenge brings him/her more points, and a failure causes him/her to jump back a number of squares. This is because the game is over when either of the players has reached the Finish square, and the game is time-constrained yet offers many chances of creative interaction.

Development and Validation Stage

The development stage entailed the physical construction of the prototype in accordance with the design requirements and expert testing to assess its suitability as a medium of learning. The validation used a Likert scale (1 = strongly disagree to 5 = strongly agree) to measure aspects of the media and the learning content. The media validation tool contained 20 questions, which were categorised into three broad aspects: material, learning, and media use, that would give an ultimate score of 100, and a 16-item material validation instrument covering content quality, language use, and presentation, that would give a maximum score of 80. The media expert assigned a total empirical score of 89 out of 100, yielding a validation percentage of 89%, which falls within the 'highly appropriate' category (Table 3). The highest scores were awarded to indicators related to material attractiveness, physical appearance, and color-image combination, reflecting the strength of the visual design. Qualitative feedback (Table 4) affirmed that the board game's aesthetic design is well-aligned with the maritime theme and that the materials are safe, durable, and practically manageable for children. The material

expert assigned a total empirical score of 72 out of 80, yielding a validation percentage of 88%, also classified as 'highly appropriate' (Table 5). The expert affirmed that the content is well-aligned with the stated learning objectives, contextually grounded in maritime environmental issues, presented in accessible language, and supported by appropriately illustrative visuals.

Table 3. Media validation components and scores

No.	Assessment Aspects	Indicator	Score
1	Material	a. Interesting material	29
		b. Physical appearance	
		c. Combination of colors and images in media	
2	Learning	a. Suitability of media to the learning environment	26
		b. Completeness of Media Components	
3	Media use	a. Suitability of media to student characteristics	34
Total			89
Percentage			89%

Table 4. Recapitulation of qualitative data from media experts

No.	Assessment Aspects	Comments and Recommendations
1	Advantages	The board game's design is attractive, with the color and visual characters chosen to match the maritime theme. The materials used are safe, durable, and easy to store.
2	Recommendations	The explanation of the reward points function and the criteria for determining winners needs to be clarified; the duration of challenges such as origami and plasticine should be extended so that children can be more creative; the sentences on the challenge cards need to be arranged in a more communicative command form; and the facilitator's explanation needs to be added that links the game objects to the concept of the maritime environment.
3	Conclusion	Suitable for testing as per revision.

Table 5. Material validation components and scores

No.	Assessment Aspects	Indicator	Score
1	Material	a. Material completeness	41
		b. Conformity to learning objectives	
		c. Breadth of material coverage	
		d. Accuracy of material	
		e. The attraction between material and media	
2	Use of Language	a. Correct use of language rules	10
3	Display	a. The attractiveness of the presentation of the material	21
Total			72
Percentage			88%

Based on the qualitative validation results summarized in Table 6, the subject matter expert provided a comprehensive evaluation encompassing the material's strengths and targeted

recommendations for refinement. Regarding its advantages, the content is deemed well-aligned with the instructional objectives and effectively contextualizes maritime environmental issues through simplified language and illustrations that support children’s cognitive development. However, several critical points require improvement prior to field implementation, including the need for a more explicit correlation between the material and core competencies, the addition of narratives regarding the urgency of marine ecosystem preservation, and the clarification of instructions for the challenge cards and origami activities to better suit the target users' abilities. Overall, the expert concluded that the media is feasible for testing, provided that these revisions are integrated to ensure pedagogical quality and contextual relevance as a thematic learning tool.

Table 6. Recapitulation of qualitative data from the results of subject matter expert validation

No.	Assessment Aspects	Comments and Recommendations
1	Advantages	The material aligns with learning objectives and is contextualized to maritime environmental issues. The language is simple and easy to understand, and the illustrations support children's understanding.
2	Recommendations	A more explicit explanation is needed regarding the relationship between the material and core competencies; add a brief description of the importance of protecting the ocean; clarify the instructions on the challenge cards; and include simple examples in the origami activities to suit children's abilities.
3	Conclusion	Suitable for testing according to revisions

The aggregate validation findings consolidated across both expert assessments are presented in Table 7. The mean feasibility of 88.5%, which is achieved when the media expert marks 89% and the material expert marks 88, puts the creative environmental and maritime-based board game squarely in the category of highly appropriate.

Table 7. Summary of overall validation results

Validator	Validation Percentage	Criteria
Media Expert	89%	Highly appropriate
Materials Expert	88%	Highly appropriate
Average	88.5%	Highly appropriate

It is on this basis that the board game has been found theoretically appropriate to be used as a learning tool and can be scaled with limited trials in future studies. The remarks and recommendations given by the experts give a clear indication of how the game can be

developed or its instructions improved before its larger application in thematic learning in elementary schools.

Discussion

The validation outcomes show that the creative board game on environmental and maritime awareness that has been created satisfies the feasibility criteria on the content and visual design. The score of 89% of the media expert and 88% of the material expert mean that they are highly appropriate and the prototype is ready to be put out in small trial cases. The findings suggest that the board game has reached a sufficient level of compatibility between a learning outcome, learning content, and the selected media format.

The pedagogical approach of the board game was designed to combine the aspects of knowledge acquisition, skill development, and sustainability values through the use of game-based learning. The professional validation demonstrates that the learning content, visual presentation, and the mechanism of the game are suitable for children between the ages of 9 and 10 years, as they prefer visual and kinesthetic learning experiences. This finding is consistent with a robust body of empirical literature affirming the capacity of board games to foster critical thinking, collaborative problem-solving, and multi-domain learning outcomes among young learners (Alotaibi, 2024; O'Neill & Holmes, 2022; Armenia et al., 2024). More specifically, the alignment of activity card categories that origami, plasticine, and storytelling with Torrance's (1966) four-dimensional creativity model (fluency, flexibility, originality, elaboration) provides a theoretically grounded basis for claiming that the game targets creative competency development in a structured and measurable manner, rather than relying on creativity as an undifferentiated construct.

The novelty of the given study is the fact that it explicitly applies the principles of DfS to the development of a children's educational board game. As operationalized through Crul and Diehl's (2009) and Vezzoli et al.'s (2018) frameworks, DfS is implemented on two levels: materially, by simulating responsible design decisions, and conceptually, by incorporating ecological themes in the work and in the challenges that children will face in the course of playing the game. This dual orientation is similar to the results of Chen and Ho (2022), who highlight that educational products covering the theme of sustainability are also effective in internalizing ecological values and enhancing the thinking over environmental questions. It is

also consistent with Putri et al. (2024), who prove that conservation-themed board games can be effective in improving the ecological literacy level of the children and their intention to act pro-environmentally.

Furthermore, the integration of Ocean Literacy principles (UNESCO-IOC, 2012) into the game's content covering marine ecosystem structure, the threats posed by plastic pollution to biodiversity, and the efficacy of individual conservation behaviors positions this board game within an internationally recognized framework for maritime environmental education. This grounding is particularly significant in the Indonesian context, where the marine environment constitutes not only a critical ecological resource but also a foundational element of national cultural and economic identity. The present study thus contributes to the nascent but growing literature on ocean literacy education in archipelagic developing nations (Surma et al., 2021), extending it to the domain of game-based learning and sustainable product design.

The findings of this research are also reminiscent of the studies on the effects of environmental and waste sorting games, as research has demonstrated that properly chosen game mechanics can facilitate the process of critical thinking and environmental literacy formation (Agustin & Aji, 2023; Arboleya García and Miralles, 2022). By combining creative challenges with concrete representations of marine ecosystems and plastic pollution problems, the activity cards invite children to engage in flexible, divergent, and elaborative thinking, which encompasses all key dimensions of Torrance's (1966) creativity framework, making the game a structured and theoretically grounded tool for creative competency development.

From the perspective of community engagement, this study demonstrates a model in which academic institutions can partner with underserved community settings, in this case, orphanage-based informal learning environments, to develop contextually responsive educational innovations. The two partner institutions contributed critically to the needs analysis and learner characterization process, ensuring that the resulting product is not merely theoretically valid but also ecologically embedded in the real learning conditions of its intended beneficiaries. This community-responsive development model aligns with the broader mandate of community service research and strengthens the societal relevance of the study beyond purely academic contributions.

Several limitations of the present study must be acknowledged. First, the research was deliberately bound to the ADD stages of the ADDIE model and does not yet extend to implementation and evaluation with child end-users. Consequently, the conclusions drawn remain at the level of expert-informed theoretical feasibility, rather than constituting empirical evidence of learning outcomes. Second, validation was conducted by only two experts in the domain, a media specialist and a content specialist. While this is consistent with practice for initial prototype development studies, it limits the breadth of perspectives captured and precludes the computation of inter-rater reliability indices. Third, while the community partner institutions provided essential contextual grounding, the children themselves did not participate as active co-designers or testers in the current phase, which represents a missed opportunity for participatory design input.

These limitations, however, simultaneously delineate clear directions for future research. Subsequent studies should advance to the Implementation and Evaluation stages of the ADDIE model, incorporating quasi-experimental or pre-post intervention designs to generate empirical evidence of the game's effects on children's creative thinking and maritime environmental knowledge. Expanding the validator panel to a minimum of five experts encompassing additional media specialists, maritime education practitioners, primary school teachers, and child development psychologists would substantially enhance the robustness and generalizability of the feasibility findings. Moreover, future development could explore digital or hybrid extensions of the game that preserve DfS principles while increasing accessibility and interactivity, in alignment with evolving 21st-century learning contexts and the increasing integration of technology in Indonesian primary education. Incorporating co-design sessions with child participants and integrating the board game into formal thematic learning units within the national *Kurikulum Merdeka* framework would further extend the impact and transferability of this educational innovation.

Conclusion

The results of the present research successfully developed and validated a creative board game integrating Design for Sustainability (DfS) principles for children aged 9-10 years. Both media and material validation indicate that the product has high feasibility with a 89% and 88% validation score, respectively, which will place the product within the highly appropriate

category. These findings indicate that the board game is effective in its pedagogical aims, namely, to increase creativity and ecological knowledge with its actual design and content structure.

The study's primary theoretical contribution lies in the demonstration that DfS principles can be systematically operationalized in the design of a children's educational board game through implementation, materially, via the exclusive use of recyclable, non-toxic components, and conceptually, via the embedding of Ocean Literacy-aligned maritime environmental content and Torrance-framework-grounded creativity activities. This integration addresses a documented gap in the literature and provides a replicable model for the development of sustainability-oriented educational products targeting creative competency development in primary school children.

From a community engagement standpoint, the study demonstrates how tertiary educational institutions, particularly those with maritime specializations, can develop community-responsive educational innovations for underserved populations. The partnership with orphanage-based informal learning environments ensured that the product is contextually grounded and immediately relevant to children who have limited access to quality creative learning media. As the present study is explicitly positioned as a first phase of a broader development project, its conclusions are appropriately bounded to expert-informed feasibility. Future research must advance to empirical implementation and evaluation with child participants, ideally within the Kurikulum Merdeka framework in coastal or riverine primary schools where maritime environmental concerns are most locally immediate. Expanding the validator panel, conducting field trials, and exploring digital or hybrid product extensions represent the logical next steps toward realizing the full educational and societal impact of this sustainability-oriented board game.

Acknowledgements

The authors thankfully acknowledge the financial support provided by the Research and Community Service Centre (P3M) of the *Politeknik Perkapalan Negeri Surabaya* (PPNS).

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