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Development of a Maritime-Based STEAM Laboratory Book to Improve Students' Problem-Solving Skills

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ABSTRACT

The lack of contextual and integrative learning media is one of the challenges in enhancing maritime literacy among students. This study aims to develop a maritime-based STEAM laboratory book that is valid, practical, and effective in improving students' understanding of maritime concepts and their problem-solving skills in science learning. The study used the Research and Development (R&D) method using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The developed product was designed based on the STEAM approach with six stages: focus, detail, discovery, implementation, presentation, and link. The validity of the book was obtained from expert evaluations, with scores of 81% for content and 85% for design, both categorized as highly valid. The practicality of the book was assessed based on teacher responses (92%) and student responses (85.4%), both of which were classified as highly practical. The effectiveness of the product was shown by student responses (83.7%), and there was an improvement in problem-solving skills.

Keywords: development, laboratory book, STEAM, problem-solving

INTRODUCTION

Indonesia, as an archipelagic country, possesses tremendous maritime potential; however, this is not yet matched by adequate quality of maritime education, especially among students. Data from Statistics Indonesia (Badan Pusat Statistik) show that the marine and fisheries sector contributes 3.5% to the national Gross Domestic Product (GDP)[1][2][3]. Unfortunately, school education still lacks meaningful integration of maritime contexts into learning, particularly in science subjects. This has resulted in students' low understanding of marine issues and their weak awareness regarding the management and preservation of marine resources[4].

The results of the initial observation at SMAIT Ulil Albab Batam revealed that students' problem-solving skills were still low. Students had difficulty in constructing mathematical models from the given problems, had difficulty in designing alternative solutions, and were unable to evaluate the correctness of their answers. These problems indicate that students are not yet trained in systematic and reflective thinking. In addition, students' interest in maritime-related themes is still limited. Therefore, there is a need for instructional materials that can encourage students to think critically while also strengthening their connection to the surrounding environment, especially marine-related issues[5].

One of the relevant learning approaches to address these challenges is STEAM (Science, Technology, Engineering, Art, and Mathematics). This approach emphasizes integrated and applicable interdisciplinary learning[6][7]. STEAM provides contextual learning experiences and promotes 21st-century skills such as creativity, collaboration, and problem-solving[8]. Several studies have shown that the use of teaching materials incorporating STEAM can enhance students' learning interest and strengthen their mastery of science concepts[9][10][11].

Research that explicitly develops a STEAM-based laboratory book with a maritime context is still very limited. This is where the novelty of this study lies: namely, in developing a maritime-based STEAM laboratory book as an interactive teaching material that integrates various disciplines with issues related to Indonesia's marine environment. This book is designed not only as a learning media but also as a tool to enhance students' understanding of maritime concepts and their ability to solve problems scientifically.

Furthermore, the development of this book aligns with the government's policy to improve the quality of education in coastal areas, which still face various challenges such as limited resources and a lack of relevant teaching materials[12]. Through the use of the STEAM approach and the integration of educational technology[13], this book is also expected to enrich students' learning experiences both digitally and

contextually. Based on the aforementioned background, the objective of this study is to develop a maritime-based STEAM laboratory book that is valid, practical, and effective in improving students' problem-solving skills.

RESEARCH METHOD

This study is a Research and Development (R&D) study[14][15] aimed at producing a product in the form of a maritime-based STEAM laboratory book model that is valid, practical, and effective in improving students' conceptual understanding and problem-solving skills[16]. The development process was based on the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. This model is considered relevant for designing and testing the quality of the product in a gradual and systematic manner [17][18].

The data sources in this study consisted of validation questionnaires addressed to expert validators with the aim of assessing the feasibility quality of the developed product, teacher and student response questionnaires intended to determine the practicality of their responses to the developed product, and test instruments used to measure the effectiveness of the developed product.

1. Data Analysis Technique
   a. Feasibility Analysis

      The feasibility of the developed product was assessed by experts using a Likert scale of 1 to 5. The assessment results were then analyzed using the feasibility percentage formula[19]:

$$P = \frac{F}{N} x\ 100\%$$

      Description:
      P : Percentage score
      F : Obtained score
      N: Maximum score

      The average score calculated from the feasibility analysis was then interpreted based on the categories presented in Table 1 below:

Table 1. Feasibility Criteria

Percentage (%)	Category
0–20	Not Feasible
21–40	Less Feasible
41–60	Moderately Feasible
61–80	Feasible
81–100	Highly Feasible

   b. Practicality Analysis

      The practicality test of the developed product was analyzed using the practicality percentage formula[20].The average practicality score was then transformed into categories as shown in Table 2 below:

Table 2. Practicality Criteria

Percentage (%)	Category
0–20	Not Practical
21–40	Less Practical
41–60	Moderately Practical
61–80	Practical
81–100	Highly Practical

   c. Effectiveness Analysis

      The effectiveness test of using the STEAM laboratory book to improve students' problem-solving skills was analyzed using the N-Gain formula [21] with a pretest-posttest control group design. The average effectiveness score was then transformed into categories as shown in Table 3 below:

Table 3. Effectiveness Criteria

N-Gain Value	Category	Criteria
≥ 0.70	High	Highly Effective
0.30 ≤ G ≤ 0.69	Medium	Effective
< 0.30	Low	Not Effective

RESULTS AND DISCUSSION

This study produced a maritime-based STEAM laboratory book model developed using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The main focus of this study lies in the development stage and limited evaluation. The initial stage (analysis) revealed that the learning process at SMAIT Ulil Albab Batam still predominantly used printed textbooks and student worksheets (LKS), without integrating innovative approaches such as STEAM. This condition does not align with the demands of the Merdeka Curriculum, which emphasizes participatory, contextual, and project-based learning approaches[22].

1. Validation of the STEAM Laboratory Book

   At the design and development stages, a storyboard was created for the book containing interdisciplinary integration of STEAM with maritime themes such as marine ecosystems, ocean mapping, and marine technology. The validation was carried out by two experts, namely a content expert and a design expert, with the following results:

Table 4. Expert Validation Results

Validation Aspect	Total Score	Maximum Score	Feasibility Percentage (%)	Category
Content Expert	81	100	81	Highly Feasible
Design Expert	85	100	85	Highly Feasible

This validation indicates that the book has met the feasibility requirements in terms of content and design. The high level of validity reflects that the product is following the principles of instructional material development[23]. According to Akbar [24], content validity is important to ensure that the learning media can deliver information accurately and align with the learning objectives[23].

2. Practicality of the STEAM Laboratory Book

Subsequently, a trial was conducted involving teachers and students to determine the level of the book's practicality:

Table 5. Practicality Results of the Book

Subject	Total Score	Maximum Score	Percentage (%)	Category
Teacher	92	100	92	Highly Practical
Students	961	1125	85.4	Highly Practical

The high practicality scores from teachers and students indicate that the book is easy to use and understand. This is in line with the study by Tesia Putri et al. [25], which found that STEAM-based modules were considered highly practical for use in science learning at the secondary school level.

3. Effectiveness of the STEAM Laboratory Book

Based on the data obtained from the post-test, it was found that there was a significant difference in students' problem-solving skills before and after being taught using the STEAM laboratory book. The comparison of problem-solving skill test results is presented in Table 6.

Table 6. Average Results of Students' Problem-Solving Skill Test

Average		N-Gain Average (%)	N-Gain Category	Effectiveness Criteria
Pre test	***Post test***			
32.05	85.41	78.5	High	Highly Effective

Based on Table 6, the average N-Gain score was 78.5, with a high category, indicating that the STEAM laboratory book is highly effective in improving students' problem-solving skills. This supports the findings of Bransford and Stein[26]in the IDEAL problem solver model, which states that students improve in problem solving when provided with contextual and integrative learning media. The use of this STEAM book has been proven to enhance students' conceptual understanding significantly.In addition, the product developed in this study provides an interdisciplinary learning experience based on local context (maritime), reinforcing students' environmental awareness and scientific literacy. The theoretical contribution of this research is to expand the development of STEAM teaching materials through contextual and locality-based approaches. Practically, this book can serve as an alternative learning medium in coastal schools that lack innovation.

The results of developing the maritime-based STEAM laboratory book model in this study show that the integration between the STEAM approach and local context (maritime) not only improves students' learning outcomes but also fosters ecological awareness and critical thinking skills. This reflection aligns with the theory of Contextual Teaching and Learning (CTL) by Elaine B. Johnson, which emphasizes that learning becomes more meaningful when connected to real experiences and students' daily lives. In this case, the maritime context serves as an authentic medium that strengthens the connection between theory and practice[29].

The main uniqueness of this study compared to previous research lies in the reinforcement of local content integration in the design of STEAM teaching materials. The studies by Putri and Zulyusri[25]as well as Tesia Putri et al [27] mostly focused on the validity and practicality of STEAM-based e-modules without contextual exploration of local elements as the main thematic foundation. In contrast, this study positions maritime issues not merely as a supporting theme but as the core pedagogy that strengthens the connection between local identity, science, and technology, thus making a more substantial contribution to the development of character-based and regionally grounded education.

From a conceptual perspective, this approach also enriches the theoretical framework of STEAM Education as proposed by Yakman [30], who emphasized the importance of interdisciplinary integration to create a holistic learning experience. However, this study adds a new dimension in the form of geographical contextualization, where the maritime aspect becomes the backbone of curriculum design, rather than merely serving as an illustration or an additional case study. This is what makes the book unique and relevant, particularly for implementation in coastal areas[31].

In addition, this reflection also reveals that one of the main obstacles in the implementation of the book is the limited laboratory facilities in schools. This becomes an important note that the

development of learning media cannot be separated from structural support and institutional policy[32], [33], [34], [35], [36]. Therefore, the role of the government and school principals in providing supporting facilities becomes crucial; thus, learning innovations like this do not stop only at the pilot project stage[37], [38], [39].

Therefore, this study not only contributes to the development of STEAM-based teaching materials but also provides a new direction in the development of regionally contextualized curricula, which have not been widely explored in previous research.

CONCLUSION

This study successfully developed a maritime-based STEAM laboratory book model that is valid, practical, and effective for improving students' problem-solving skills in coastal areas. The development using the ADDIE model resulted in a learning product integrated with an interdisciplinary approach (science, technology, engineering, arts, and mathematics), which is not only relevant in terms of content but also applicable in the local context. Validation from experts showed a high level of feasibility (content validation 81% and design 85%), while the practicality test by teachers and students showed scores of 92% and 85.4%, respectively. The effectiveness test showed a significant increase from the pretest to the posttest scores, with an N-Gain value of 0.6681, indicating the progressiveness of students' problem-solving skills. Overall, this product has been proven to encourage active student engagement, enhance conceptual understanding, and provide a meaningful learning experience. Meanwhile, the implications of the developed product consist of;

1. Theoretical Implications:

   This study reinforces constructivist learning theory, which emphasizes the importance of active student engagement in the learning process through exploratory and context-based activities. The maritime-based STEAM laboratory book model supports students' knowledge construction through direct experience and real-world problem solving. This study also contributes to the development of literature on the integration of STEAM education with local wisdom, particularly in the context of maritime education.
2. Practical Implications:

   This product canserve as an alternative solution for schools in coastal areas that require contextual and interactive teaching materials. Teachers can use this book as a guide for designing more active and meaningful learning. Additionally, this book can also be utilized by education policymakers as a model for developing contextual curricula based on regional potential.
3. Policy Implications:

   The results of this study can serve as a basis for the Department of Education and related stakeholders to develop policies that strengthen education based on local potential. In the long term, the implementation of the STEAM-based laboratory book model can help prepare the younger generation to face challenges in the maritime sector and strengthen educational resilience in coastal areas.

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