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Madura's Local Wisdom in a Global Context: Developing an E-Book to Foster Critical Thinking on Climate Issues

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Abstract: This research aims to produce a valid and effective problem-based learning e-book integrated with Madura's local wisdom to enhance students' critical thinking skills. This study employed a Research and Development (R&D) method with the ASSURE model, which includes the stages: analyze learner characteristics, state objectives, select, modify or design media, utilize media, require learner response, and evaluate. The subjects of this research were 20 students from class X at State Senior High School 4 Bangkalan, Madura Regency. The research instruments used included expert validation sheets, observation sheets for learning implementation, pre-test and post-test critical thinking skills, and student response questionnaires. Data analysis used the quantitative descriptive method. The research results show that this problem-based e-book received a high validity index score in terms of content feasibility, presentation, and language, categorizing it as valid with an average score of 3.13. The implementation of learning achieved a high percentage score of 80% with practical criteria. Based on post-test results, 90% learning completeness was obtained. The N-Gain pretest-posttest calculation results indicate an average N-Gain score of 0.71 with high criteria. The improvement in critical thinking indicator achievement had an average N-Gain score of 0.78, and the positive response from students towards the use of the e-book reached 90.76% with very good criteria. The results of this study affirm that the problem-based e-book integrated with Madura's local wisdom is capable of significantly enhancing students' critical thinking skills.

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Introduction

21st-century learning emphasizes students' ability to seek knowledge, formulate problems, think analytically, and collaborate (Kemendikbud, 2017). These competencies, including digital and technological literacy (Trilling & Fadel, 2009), are relevant to the Merdeka Curriculum, which integrates the issue of preserving Siring Kemuning Beach (Hidayat, 2023), and are a response to the global challenges of the Society 5.0 era (Fukuyama, 2018).

The development of educational technology has introduced AI-based learning media innovations capable of mimicking human thinking. In the context of education, AI is utilized to monitor online learning activities, assess answers, provide quick feedback, and personalize learning according to students' abilities (Raharjo, 2023). AI also supports the development of critical thinking thru broad access to information, text analysis, and explanations of complex concepts (Holmes et al., 2019) and (Luckin et al., 2016). Technologies like ChatGPT, GitHub Copilot, Google Gemini, and Perplexity AI accelerate access to information while encouraging students to critically analyze, evaluate, and reflect on knowledge, which is relevant for integration with the Siring Kemuning Tanjung Bumi coastal ecosystem.

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Siring Kemuning Beach requires preservation related to beach cleanliness, beach biota, and so on. In addition, there is local wisdom, especially in the Madura region, known as "Rokat Tase," which is a community ceremony that reflects the fishermen's gratitude and aims to protect them from disasters and any obstacles they might face while at sea, as well as to ensure a bountiful catch. This creates learning that trains critical and meaningful thinking, as proposed by Ausubel, which is a process where students relate new information to concepts that already exist in their cognitive structure (Ausubel, 1963).

Critical thinking is an effort to gather, interpret, analyze, and evaluate with the aim of drawing reliable and valid conclusions. Critical thinking includes interpretation, analysis, conclusion, evaluation, explanation, and self-regulation (Facione, 2013). Critical thinking is the ability to make rational decisions about what should be done or believed (Slavin, 2011). The ability to think critically has become a demand in the Society 5.0 era, making it important to train students in this skill, one of which can be done through the use of media such as e-books.

E-book is defined as "text on a screen," and it is another form of an electronic book. The use of e-books can stimulate students' interest in studying them by applying PBL syntax and supported by features that can train students' critical thinking skills. Therefore, the benefits obtained from the use of e-books in the learning process are as multimedia tools (such as audio, video, animations) that can attract students' attention (Haning Hasbiyati, 2017) and (Vassiliou & Rowley, 2008). In this study, the e-book for training critical thinking is implemented in the PBL learning model. The conclusions drawn are based on empirical evidence. The e-book for training critical thinking skills can be optimized through the Problem Based Learning (PBL) model.

Several previous studies have developed problem-based e-books to improve students' critical thinking skills (Lestari, 2021) and (Prasetyo, 2022). Other research shows that learning integrated with local wisdom can improve students' understanding and pro-environmental attitudes (Rahmawati, 2020). Meanwhile, several studies have also discussed the use of artificial intelligence (AI) in supporting adaptive learning (Holmes et al., 2019) and (Raharjo, 2023). However, these studies are still isolated and have not linked the use of problem-based e-books, the integration of Madurese local wisdom, and the utilization of contextual issues from Siring Kemuning Beach and the Rokat Tase tradition in biology learning. Thus, there is a research gap in developing learning models that are not only academically effective but also relevant to students' cultural and environmental context. This research aims to fill that gap.

Problem Based Learning (PBL) is an educational method that encourages students to learn how to study and work together in groups to find solutions to real-world problems. PBL also involves logical analysis and critical thinking, the use of analogies and divergent thinking, as well as creative integration and synthesis (oon-seng, 2003). Problem-Based Learning is considered one of the effective strategies that contribute to the development of students' cognitive and critical thinking abilities. PBL in this study focuses on authentic problems related to the issues of sustainability, safety, cleanliness, and conservation of the Siring Kemuning beach. The novelty of this research lies in the development of an e-book based on the local wisdom of Siring Kemuning, integrated with the Merdeka Curriculum and supported by the utilization of artificial intelligence (AI) technology. Previous research has focused more on conventional or general digital teaching materials, without directly linking local environmental issues to the strengthening of the Pancasila Student Profile and 21st-century skills. Therefore, this research aims to produce a valid, practical, and effective e-book

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on Siring Kemuning local wisdom for training critical thinking skills, increasing learning motivation, and optimizing student learning outcomes in biology lessons.

Research Method

The type of research is a study using the Research & Development development model with the ASSURE Russell Model (2014), which consists of six stages: analyze learner characteristics, state objectives, select, modify or design media, utilize media, require learner response, and evaluate. Validation of the PBL e-book based on local wisdom "Rokat Tase" at Siring Kemuning Beach was given to validators, namely biology lecturers or media learning experts and high school biology teachers. The validation results serve as a guideline for improving the e-book based on the validators' suggestions. The practicality test and questionnaire contain instruments to examine how the implementation and student response to the local wisdom-based PBL e-book "Rokat Tase" at Pantai Siring Kemuning Tanjung Bumi. The Effectiveness test includes instruments for testing Critical Thinking skills and a response questionnaire for students through the student response questionnaire sheet.

Results and Discussion

The PBL-based e-book developed contains learning syntax thru bio-material, bio-discussion, bio-info, bio-investigation, and bio-solution features to train students' critical thinking skills. The material covers three subtopics: climate and its changes, the greenhouse effect, and adaptation and mitigation based on local wisdom. In the climate subtopic, students studied global climate change linked to reforestation activities using moringa plants.

The greenhouse effect subtopic focused on the practice of making organic fertilizer as a solution to reduce methane gas emissions. Meanwhile, the adaptation and mitigation subtopic emphasizes the analysis of Rokat Tase local wisdom and the creation of biopores to maintain environmental sustainability. The integration of science, AI technology, and local culture in this e-book is able to provide a meaningful learning experience while also fostering students' critical thinking skills.

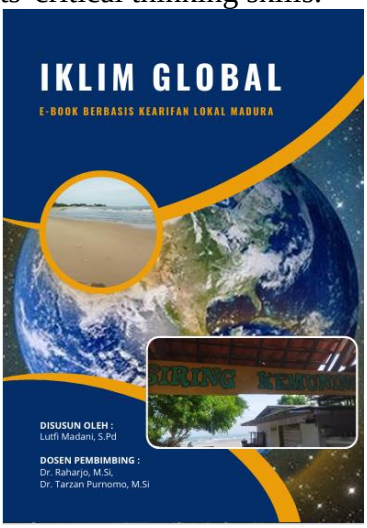

Figure 1. Cover *e-book*

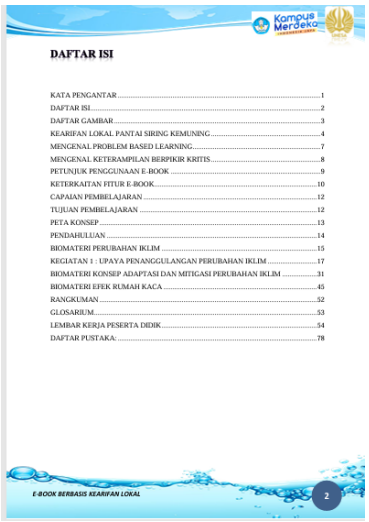

Figure 2. Table of contents *e-book*

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Figure 3. Feature Bio Info *e-book*

Figure 4. Feature Bio Materi *e-book*

Figure 5. Feature Bio Diskusi *e-book*

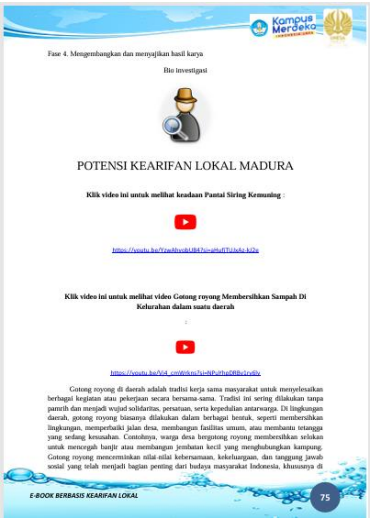

Figure 6. Feature Bio Investigasi *e-book*

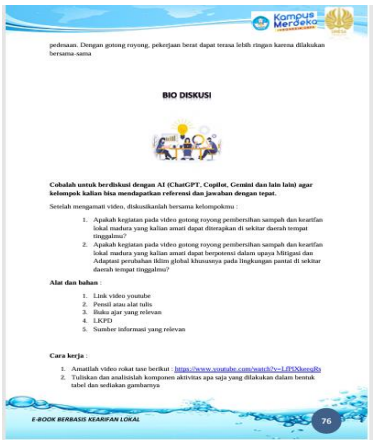

Figure 7. Bio Solusi *e-book*

The developed product consists of learning tools and an E-book on Problem-Based Learning Based on Local Wisdom of Ecotourism in Siring Kemuning Tanjung Bumi, Assisted by AI Global Climate Material to Train Critical Thinking. Before testing. this product on students, validation was conducted. The lecturers who evaluate the e-book are

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subject matter experts and media experts. The validity of this e-book aims to produce a valid and usable e-book. The components of the validation assessment include aspects: presentation validity, content validity, language validity, achievement of PBL syntax, content suitability within the scope of local wisdom, and achievement of critical thinking skills. Figure 1 shows the cover that represents the content of the e-book, which is about global climate material integrated with local Madura wisdom using the Problem Based Learning model. Figure 2 shows the table of contents that facilitates the content of the e-book. Figure 3 contains information through videos or news. Figure 4 contains a study of relevant material with an authentic basis. Figure 5 contains activities analyzing discussion and practical questions. Figure 6 presents the students' works based on their research. Figure 7 shows the final problem-solving activities.

Table 1. E-book Validation Recapitulation Results

Aspects Evaluated	Average Score	Category
Presentation Validity	3,19	Valid
Content Validity	3,00	Valid
E-book Systematics	3,25	Very Valid
Language Validity	3,00	Valid
PBL Syntax Achievement	3,40	Very Valid
Content Alignment with Critical Thinking Skills in Local Wisdom	3,00	Valid
Critical Thinking Skills Achievement	3,10	Valid
Overall Average	3,13	Valid

Thus, the locally wisdom-based PBL e-book developed is declared highly valid. This is because the e-book has a colorful display quality accompanied by images and videos that support the material with good resolution.

The designed e-book must meet the presentation validity criteria. Who stated that good presentation quality is very important to motivate students in learning, and the e-book contains simulations by combining discourse/text, videos, images, and accompanied by activity guides, making learning more interactive (Lathifah & Utami, 2021). Based on the presentation validity results from media expert lecturers, there are aspects that are not yet optimal, namely content validity 3.0; language validity 3.0; and content suitability with critical thinking skills within the scope of local wisdom 3.0. Considering these results, the researcher made improvements to the e-book according to the suggestions and feedback from the validators.

The e-book developed based on learning outcomes can help achieve learning objectives on global climate material. The use of media aims to enhance student motivation to acquire skills and actively participate in the learning process at school, thereby deepening their understanding of the subject matter (Fitriyah & Ghofur, 2021),. The validity results of the e-book show that there are several aspects that have not yet reached optimal scores, namely in the aspects of content validity, language, and local wisdom content. However, in terms of presentation quality, the e-book's systematics scored 3.25, and the achievement of PBL syntax criteria is very valid.

The aspect of presentation validity, a score of 3.19 was obtained in the valid category with specifications of e-book display 3.12, e-book usage 3.5, layout quality 3.0, image quality 3.3, and video quality 3.0. The aspects categorized as optimal are the e-book display, e-book usage, and image quality. This is because the e-book has an attractive color display and color combinations that can motivate students in learning. The e-book is easy to use because it has easily accessible navigation and allows for easy page turning to the next page. The e-book

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has attractive and clear image quality, which motivates students to delve into new things, especially images that display real content. However, the layout quality and video quality aspects are less than optimal. In the e-book, it should display an attractive layout and engaging videos so that students can interact more easily and be motivated to learn. Next, the researcher made revisions according to the suggestions and feedback from the validators. The components of an e-book include: 1) design modification, 2) the use of appropriate font size and shape, 3) the availability of hyperlinks to facilitate access to additional information, 4) ease of obtaining the e-book, 5) the availability of auxiliary words or a dictionary to help readers understand difficult words, 6) the use of color or highlights on important sentences or providing notes, 7) practicality in accessing it anywhere and in any situation, 8) cost-effectiveness, 9) and the suitability of the e-book as a learning medium in the teaching and learning process. So, it is very important in optimizing the quality of e-books thereby motivating students to learn more effectively (Wang, 2015).

On the aspect of content validity, a score of 3.0 was obtained in the valid category with the specifications of concept suitability 3.0, the quality of concept suitability with the independent curriculum 3.0, the currency and contextuality of the concept 3.16, and activities in the e-book that facilitate critical thinking skills 3.0. The aspect categorized as optimal is the currency and contextuality of the concept. This means the e-book has contextual and authentic concepts. This allows students to explore material related to the real world. However, in terms of concept alignment, the quality of concept alignment with the independent curriculum and the facilitation of critical thinking skills is less than optimal. In the e-book, attention should be paid to concepts that align with the goal of enhancing critical thinking skills, with an emphasis on critical thinking components. Concepts packaged with real-world relevance greatly assist students in practicing critical thinking. Critical thinking skills train students to solve problems related to real life. So, it is very important in optimizing the quality of e-books so that students are motivated to learn (Yaldız & Bailey, 2019).

The validity of the e-book systematics is 3.25, categorized as very valid. This is in terms of the e-book cover, introduction, and content, which present an attractive appearance. The media components, which consist of the cover, introduction, and content, are very important in student learning and motivation, and they encourage students to learn more easily in order to achieve a goal of critical thinking. Learning media are tools used to deliver learning materials with the aim of stimulating students' interest and attention so that they become more active in the learning process. This media functions as an intermediary that helps convey information effectively, allowing students to better understand the material and making the learning process more engaging and interactive (Gagne & Briggs, 2020). Choosing media as a source of independent learning can add variety to students' learning experiences while also preparing them to be more ready to receive the material that will be presented in the next session. Thus, the media plays an important role in supporting a more effective and directed learning process, such as e-books that are packaged according to the learning material and designed attractively to foster student motivation, enhancing learners' motivation to conduct investigations to find solutions to the problems faced.

The validity of the language falls into the valid category with a score of 3.0. The aspect of language is very important for the continuity of learning. Because using standard language, in accordance with EYD, and language that is easy to understand makes students enthusiastic about learning. Language in books serves as a tool for representing the author's thoughts and feelings, and as a medium of indirect communication between the author and

the reader (Sugihastuti, 2020). So, language is very important in achieving the goal of developing critical thinking skills.

The validity of the content's alignment with critical thinking skills within the scope of local wisdom received a score of 3.0. However, this needs to be optimized in the local wisdom content. The local wisdom content should be presented through videos or photos directly related to the targeted local wisdom and should be authentic. This should also be presented according to real content and can achieve the PBL syntax that will later train students' critical thinking. Problem-Based Learning is a teaching strategy where students are actively confronted with complex problems in real situations (Glazer, 2001). PBL can enhance critical thinking skills (Marzuki & Basariah, 2017) and (Silva et al., 2018). Students are more motivated to engage in the learning process with the PBL model, thereby improving their critical thinking abilities (Setyosari & Sumarmi, 2017). The validity of the achievement of critical thinking skills was obtained at a valid category of 3.1.

The indicators of critical thinking skills practiced in the e-book activities include: interpretation, analysis, evaluation, inference, explanation (Facione, 2013). Activities that foster critical thinking skills are reflected in the five features of the e-book. In the features Bio-material and Bio-info, Bio-discussion, Bio-investigation, and Bio-solution. Bio-material, students are invited to examine the material, concepts, causes, and effects of the impact of an issue on the topic. Bio-info, students are invited to dig for information and think about how to address an issue. Bio-discussion, students are invited to discuss individually or in groups to analyze questions about an issue that occurs. Bio-investigation, students are invited to plan and formulate solutions to the problem (in the form of practical work). This activity is also inseparable from learning activities assisted by Artificial Intelligence (AI) technology to generate practical work ideas, problem formulation, and plan practical objectives for works as solutions to problems. Bio – solution, Students are invited to analyze, conclude, and evaluate the results of practical work in addressing problem-solving related to the discussed topic. when students encounter an authentic problem in the form of local wisdom, they need to analyze or clarify the provided data (clarification), evaluate or assess by giving reasons or examples (assessment), draw conclusions or inferences, and formulate problem-solving strategies (Susilo, 2022).

Data on the achievement of critical thinking skills were obtained through pretest and posttest results. The effectiveness analysis of the e-book in training critical thinking skills was conducted by analyzing the completeness of student learning outcomes after they participated in the pretest and posttest. The pretest and posttest questions consist of 7 essay questions that were previously validated by 2 (two) validator lecturers, and the results of pretest and posttest can be seen in the Table 2

Table 2. Result of pretest and posttest

Value	N	Score Ideal	Score Minimum	Score Maximum	average	Average N - Gain	Gain Criteria
Pre-test	20	100	20	54	37,0	0,71	High
Posttest	20	100	64	92	81,9		

The results of the critical thinking skills test showed that the pretest achieved 0% mastery, while the posttest increased to 90% or 18 students reached the minimum passing score. The N-Gain calculation ranged from 0.54 to 0.85 with an average of 0.71 (high category), thus proving that the use of Problem-Based Learning-based e-books is effective in improving students' critical thinking skills. This condition is understandable considering that critical

thinking is a higher-order thinking skill that does not develop automatically, but needs to be trained through the appropriate learning approach (Setiawan & Sukmawati, 2021).

Table 3. The increase in N-gain scores for each critical thinking indicator

No	Indicator	Number of test	Result		*N-gain score*	Mean	Criteria
			Pretest	*Posttest*			
1.	Interpretation	1	4,3	9,3	0,88	0,88	High
2.	Analysis	2	5,8	9,1	0,80	0,80	High
3.	Evaluation	3	6,4	13,1	0,76	0,77	High
		4	6,0	13,0	0,78		
4.	Conclusion	5	6,2	12,8	0,75	0,73	High
		6	5,9	12,5	0,72		
5.	Explanation	7	8,7	16,8	0,71	0,71	High
Mean						0,78	High

The value of the critical thinking skills indicators shows an improvement based on the pretest and posttest results. The most dominant improvement in the achievement of critical thinking indicators is in the interpretation indicator with an N-Gain value of 0.88, but the explanation and self-regulation indicators achieved lower values compared to the other indicators, reaching an N-Gain value of 0.71. Overall, the five critical thinking skills indicators can be mastered by the students, obtaining a score of 0.78, categorized as high. After conducting the learning using PBL-based e-books, there was a significant improvement in the posttest results, with 90% of the students (18 out of 20) achieving learning completeness. This change indicates that the learning intervention was able to help students develop the ability to analyze, evaluate, and draw conclusions from the information obtained, which is the core of critical thinkingskills.

The improvement in student learning outcomes was analyzed using the Normalized Gain (N-Gain) formula. The calculation results showed that the lowest N-Gain value was 0.54 and the highest was 0.85, with an average of 0.71, which falls into the high category. An N-Gain value > 0.7 is categorized as a high improvement, indicating a strong influence of the provided learning treatment on students' critical thinking abilities (Fitriani & Kurniawan, 2021). The PBL model has characteristics that greatly support the development of critical thinking skills. Critical thinking skills are developed through PBL, which invites students to deeply analyze various complex real-world problems, organize information, formulate hypotheses, evaluate alternatives, and devise solutions. In the e-book used, the entire PBL syntax, from problem orientation, task organization, independent investigation, development and presentation of results, to reflection, is systematically implemented in the form of integrated materials and activities. The use of PBL-based e-books can enrich students' learning experiences because they do not just receive information, but also actively engage in exploration and problem-solving (Pratiwi et al., 2022).

This allows for the formation of more meaningful understanding, as well as training students in decision-making and reflective thinking, which are indicators of critical thinking. In addition, the advantages of the e-book used in this study also lie in its attractive, interactive design, and ease of access through digital devices. Who state that well-developed e-books can enhance learning motivation, learning independence, and cognitive engagement of students in problem-based learning (Kurniawan & Lestari, 2023). By examining the learning completeness data, N-Gain scores, and supporting theoretical studies, it can be concluded that

PBL-based e-books are very effective in enhancing students' critical thinking skills. This device is not only suitable for use in learning contexts oriented towards real problem-solving but also relevant to the demands of the Merdeka Curriculum, which emphasizes character strengthening, 21st-century competencies, and contextual learning

Conclusion

This research produced a problem-based learning e-book based on local wisdom of ecotourism in Siring Kemuning Tanjung Bumi assisted by ai on global climate material to train critical thinking, which is feasible and valid with an overall average score of 3.13, reviewed from the aspects of presentation validation, content validity, language validity, PBL syntax achievement, content suitability with local wisdom within the scope of local wisdom, and the achievement of critical thinking skills. The posttest results showed a 90% learning completeness, meaning 18 students have achieved the established KKTP. The lowest N-Gain score is 0.54 and the highest is 0.85. The N-Gain calculation results show that the average N-Gain score is 0.71, which falls under the high criteria.

Recommendation

For teachers, the Siring Kemuning local wisdom e-book can be used as an innovative learning medium that trains critical thinking skills while fostering care for culture and the environment. Meanwhile, for future researchers, it is recommended to develop e-books for different subjects or grade levels and integrate AI technology more interactively, for example, thru automated assessment features, so that the research results can further enrich educational practices in the 21st century.

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