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Needs Analysis for Developing a Coastal Ecosystem-Integrated POPBL E-Module to Support Creative Thinking Skills in Indonesian Junior High School Science Education

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ABSTRACT

Developing creative thinking skills in biology education requires contextual, student-centered learning supported by appropriate digital resources. However, limited integration of local environmental contexts and project-oriented activities may hinder students' creative thinking development. This study aimed to identify instructional needs for developing a coastal ecosystem-integrated Project-Oriented Problem-Based Learning (POPBL) e-module to support creative thinking skills. An exploratory sequential mixed-methods design was employed involving one teacher and 20 seventh-grade students at SMP Negeri 10 Kupang, Indonesia. Data were collected through semi-structured interviews, student needs questionnaires, and creative thinking tests. Quantitative data were analyzed descriptively, while qualitative data were examined using thematic analysis. Findings were integrated to identify instructional needs and inform e-module design. The findings revealed limited implementation of project-based activities (25%) and insufficient integration of coastal ecosystem contexts (40%). All students (100%) expressed a need for digital learning resources and supported multimedia-based materials. Creative thinking performance was categorized as very low across fluency (30%), flexibility (35%), originality (35%), and elaboration (30%). Teacher interviews further identified predominantly conventional instruction and limited utilization of contextual digital materials. The findings indicate a need for contextual digital resources integrating authentic coastal environmental problems with project-oriented learning activities. These results provide an empirical foundation for designing a coastal ecosystem-integrated POPBL e-module targeting students' creative thinking skills, although its effectiveness requires further investigation.

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1. INTRODUCTION

The rapid advancement of science, technology, and digital transformation has fundamentally changed the competencies required of learners in the twenty-first century. Educational systems are increasingly expected to prepare students not only with conceptual knowledge but also with higher-order thinking skills that enable them to adapt, innovate, and solve complex real-world problems. Among these competencies, creative thinking has been widely recognized as a critical skill because it allows learners to generate original ideas, develop innovative solutions, and respond effectively to emerging challenges in society. Creative thinking is considered one of the core dimensions of twenty-first-century learning and has become an important indicator of educational quality in science education (Dilekçi & Karatay, 2023; Pinar, 2025). Consequently, developing students' creative thinking skills has become a major priority in biology education.

Biology learning provides substantial opportunities for developing creativity because biological phenomena are closely related to everyday life and environmental issues. However, many biology classrooms continue to rely on teacher-centered instructional approaches that emphasize memorization and factual knowledge rather than inquiry, innovation, and problem-solving. Such practices often limit students' opportunities to explore ideas, formulate solutions, and construct meaningful understanding independently. Recent studies have shown that traditional instruction remains one of the major barriers to the development of creative thinking skills in science education (Affandy et al., 2024; Ramdani et al., 2022). As a result, students frequently demonstrate low performance in fluency, flexibility, originality, and elaboration, which are the essential dimensions of creative thinking.

To address these challenges, contemporary educational research has emphasized the importance of student-centered learning approaches. One instructional model that has attracted considerable attention is Project-Oriented Problem-Based Learning (POPBL). This approach combines the strengths of problem-based learning and project-based learning by engaging students in authentic problem-solving activities that culminate in the creation of meaningful products or solutions. Through POPBL, students are encouraged to investigate real-world issues, collaborate with peers, apply scientific knowledge, and develop creative solutions to contextual problems. Previous studies have demonstrated that project-based and problem-based learning approaches significantly improve students' creativity, engagement, critical thinking, and twenty-first-century skills (Zhang & Ma, 2023; Rehman et al., 2024; Smith et al., 2022). Furthermore, integrating creative pedagogy within problem-based learning environments has been shown to promote students' ability to generate innovative ideas and construct original solutions (Affandy et al., 2024).

The effectiveness of POPBL can be further enhanced through the integration of digital learning resources. Advances in educational technology have created opportunities to transform conventional learning materials into interactive digital formats that facilitate independent and flexible learning. E-modules have emerged as one of the most promising forms of digital instructional resources because they combine textual content, multimedia elements, simulations, videos, and interactive assessments within a single learning environment. Research indicates that digital learning materials can increase student engagement, improve conceptual understanding, and support the development of higher-order thinking skills (Asrizal et al., 2023; Puspita et al., 2024). In addition, interactive e-modules designed using project-based learning principles have been found to positively influence students' creative thinking and collaborative abilities (Aliyah & Widiyatmoko, 2022).

Despite these advantages, many digital learning resources currently used in schools remain disconnected from students' local environments and socio-cultural contexts. Contemporary educational theories emphasize that meaningful learning occurs when new knowledge is connected to learners' real-life experiences and surrounding environments. Therefore, integrating local wisdom and local environmental resources into instructional materials has become increasingly important. Contextual learning not only improves students' understanding of scientific concepts but also strengthens environmental awareness and cultural identity (Syahfitri & Muntahanah, 2024). In this regard, coastal ecosystems represent valuable learning resources for biology education because they

provide authentic contexts for understanding biodiversity, ecological interactions, environmental conservation, and sustainability issues.

East Nusa Tenggara (NTT), Indonesia, possesses diverse coastal ecosystems, including coral reefs, mangrove forests, seagrass beds, and marine biodiversity of significant ecological value. These ecosystems offer rich opportunities for contextual biology learning and environmental literacy development. Moreover, integrating local coastal resources into science education aligns with the principles of Education for Sustainable Development (ESD), which encourages learners to understand environmental challenges and participate actively in sustainable solutions. Recent studies have highlighted the importance of contextual and sustainability-oriented learning approaches in fostering creativity, environmental responsibility, and meaningful learning experiences (Makhrus et al., 2025; Sukri et al., 2023).

Several previous studies have investigated the relationship between project-based learning, digital learning resources, and creative thinking. First, Zhang and Ma (2023) conducted a meta-analysis demonstrating that project-based learning positively influences students' learning outcomes and higher-order thinking skills. However, the study focused primarily on general educational contexts and did not explore the integration of local environmental resources into project-based learning. Second, Puspita et al. (2024) developed a PBL-STEM interactive e-module that successfully improved students' creative thinking skills. Nevertheless, the study emphasized STEM integration and did not incorporate local ecological contexts as meaningful learning resources. Third, Syahfitri and Muntahanah (2024) examined the effectiveness of local wisdom-based digital modules and found positive impacts on students' thinking skills. However, the study did not utilize a POPBL framework and was not specifically designed to foster creative thinking in biology learning.

A critical analysis of these studies reveals several important limitations. Existing research tends to examine project-based learning, digital learning materials, creative thinking, and local wisdom integration separately rather than holistically. While some studies focus on project-based approaches, they often overlook contextual environmental resources. Conversely, studies integrating local wisdom frequently lack strong pedagogical frameworks capable of promoting higher-order thinking skills. Moreover, research specifically examining the integration of coastal ecosystem contexts into POPBL-based e-modules for biology learning remains scarce. This situation indicates a significant research gap regarding the development of contextual digital learning resources that simultaneously integrate POPBL principles, coastal ecosystem content, and creative thinking skill development.

The novelty of the present study lies in its attempt to bridge this gap by exploring the need for a POPBL-based e-module that integrates the coastal ecosystems of East Nusa Tenggara as a contextual learning resource for biology education. Unlike previous studies, this research combines three strategic components: Project-Oriented Problem-Based Learning, digital e-module technology, and coastal ecosystem contextualization. Furthermore, the study focuses specifically on enhancing creative thinking skills, which are increasingly recognized as essential competencies for twenty-first-century learners and sustainable development.

Considering the importance of creative thinking, contextual biology learning, and digital transformation in education, understanding the actual needs of teachers and students is a crucial preliminary step before developing an innovative instructional product. Therefore, this study seeks to investigate the extent to which teachers and students require a coastal ecosystem-integrated POPBL e-module in biology learning and how such a learning resource can potentially support the development of students' creative thinking skills. The findings are expected to provide empirical foundations for the design and development of contextual digital learning materials that promote meaningful learning, environmental awareness, and creative thinking among secondary school students.

2. METHODS

2.1 Research Design

This study employed a mixed-methods approach using an exploratory sequential design to investigate the need for developing a Coastal Ecosystem-Integrated Project-Oriented Problem-Based Learning (POPBL) e-module for biology learning. The mixed-methods approach was selected because it enables a comprehensive exploration of educational needs by integrating qualitative and quantitative data. Qualitative data were collected to gain an in-depth understanding of teachers' and students' experiences, challenges, and expectations regarding biology learning and digital instructional materials. Quantitative data were used to identify students' perceptions of current learning practices and to examine their creative thinking skills profile. The integration of both forms of data provided a robust empirical foundation for determining the necessity and direction of e-module development.

The exploratory sequential design was implemented in two stages. First, qualitative data were gathered through teacher interviews to identify instructional challenges, learning resource limitations, and opportunities for integrating local coastal ecosystem contexts into biology learning. Second, quantitative data were collected through student questionnaires and creative thinking skills tests to validate and complement the qualitative findings. The results from both stages were subsequently integrated to formulate recommendations for the development of a contextual POPBL-based e-module.

2.2 Research Setting and Participants

The study was conducted at SMP Negeri 10 Kupang, East Nusa Tenggara, Indonesia, during the 2025/2026 academic year. The school was purposively selected because of its geographical proximity to coastal ecosystems, which are highly relevant to the contextual learning content proposed in this study. The participants consisted of one biology teacher and twenty Grade VII students. The teacher was selected based on teaching experience and direct involvement in biology instruction. Students were selected using purposive sampling because they had previously studied ecosystem-related topics and were considered capable of providing relevant information regarding learning experiences, learning needs, and digital learning preferences. As a preliminary needs analysis study, the focus was not on statistical generalization but on obtaining contextual and in-depth information that could support the design of an innovative learning resource tailored to local educational needs.

2.3 Research Instruments

Three instruments were employed to collect data: a teacher interview guide, a student needs analysis questionnaire, and a creative thinking skills test.

2.3.1 Teacher Interview Guide

A semi-structured interview guide was developed to explore teachers' perspectives regarding current biology teaching practices, implementation of student-centered learning approaches, utilization of technology in learning, integration of local environmental resources, and the need for innovative digital instructional materials. The interview consisted of eight open-ended questions designed to generate detailed information concerning instructional challenges and expectations for future learning resources.

2.3.2 Student Needs Analysis Questionnaire

The student questionnaire was designed to identify learners' perceptions of biology learning, difficulties encountered during instruction, experiences with project-based activities, utilization of digital learning resources, and expectations regarding future instructional materials. The questionnaire consisted of twenty items measured using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). To ensure content validity, the questionnaire was reviewed by three experts in biology education, educational technology, and curriculum development. Content validity was assessed using Aiken's V coefficient, and all items met the acceptable validity criteria. Instrument reliability was evaluated using Cronbach's Alpha, indicating satisfactory internal consistency for educational research purposes.

2.3.3 Creative Thinking Skills Test

Students' creative thinking skills were assessed using an essay-based test consisting of four open-ended questions developed according to Guilford's dimensions of creativity. The test measured four indicators of creative thinking: fluency, flexibility, originality, and elaboration. Each question was designed within the context of ecosystem-related biological issues to encourage students to generate creative and contextually relevant responses. The test instrument was evaluated by three experts in biology education and educational assessment to ensure content relevance, construct validity, and language clarity before administration.

Table 1. Indicators of Creative Thinking Skills

Indicator	Description
Fluency	Ability to generate multiple relevant ideas or solutions to a given problem
Flexibility	Ability to propose diverse perspectives and alternative approaches to solving problems
Originality	Ability to produce unique, uncommon, and innovative responses
Elaboration	Ability to expand, refine, and explain ideas in a detailed and comprehensive manner

2.4 Data Collection Procedures

Data collection was conducted in three stages. First, semi-structured interviews were conducted with the biology teacher to obtain qualitative information regarding instructional practices, learning challenges, technology integration, and the use of local environmental contexts in biology education. Second, the student needs analysis questionnaire was administered to identify students' perceptions of current learning conditions and their expectations regarding digital learning resources. The questionnaire was completed during regular classroom sessions under the supervision of the researcher and the classroom teacher. Third, students completed the creative thinking skills test to determine their baseline creative thinking profile prior to the development of the proposed e-module. The test was administered under standardized classroom conditions to ensure consistency in data collection.

2.5 Data Analysis

Qualitative and quantitative data were analyzed separately and then integrated during the interpretation stage. Quantitative data obtained from the questionnaires and creative thinking tests were analyzed descriptively using percentages, means, and standard deviations. The analysis aimed to identify patterns of learning needs, students' perceptions of current instructional practices, and the overall profile of creative thinking skills.

Qualitative interview data were analyzed using thematic analysis following the procedures proposed by Braun and Clarke. The analysis involved data familiarization, coding, theme generation, theme review, theme definition, and interpretation. Emerging themes were used to identify major instructional challenges, learning needs, and expectations regarding the development of contextual digital learning materials. To enhance the credibility of the findings, data triangulation was conducted by comparing information obtained from interviews, questionnaires, and creative thinking assessments. The integration of multiple data sources enabled a more comprehensive understanding of the educational needs underlying the development of the proposed e-module.

2.6 Ethical Considerations

This study adhered to ethical principles in educational research. Permission to conduct the study was obtained from the school administration prior to data collection. All participants were informed about the objectives of the research, the voluntary nature of participation, and the confidentiality of the collected data. Participants were assured that their responses would be used exclusively for academic purposes and reported anonymously to protect their privacy.

3. FINDINGS AND DISCUSSION

3.1 Teacher Needs Analysis

The interview findings revealed a substantial discrepancy between the expectations of twenty-first-century biology education and the instructional practices currently implemented in the classroom. Four major themes emerged from the analysis: (1) predominance of teacher-centered instruction, (2) limited implementation of project-oriented learning activities, (3) insufficient integration of local environmental contexts, and (4) the need for innovative digital learning resources.

Table 2. Summary of Teacher Needs Analysis

Aspect	Findings
Learning approach	Predominantly lecture-based and discussion-oriented
Project-based learning implementation	Rarely implemented
Assessment practice	Focused mainly on conceptual understanding
Creative thinking assessment	Not systematically conducted
Integration of coastal ecosystem content	Limited
Use of digital learning resources	Minimal
Technological facilities	Adequate
Need for POPBL-based e-module	Strongly needed

The teacher reported that biology instruction is still dominated by content transmission rather than inquiry-based knowledge construction. Although students occasionally participate in classroom discussions, opportunities to engage in authentic investigations, project development, and problem-solving activities remain limited. Consequently, learning tends to emphasize conceptual recall rather than the development of higher-order thinking skills.

Another important finding concerns the limited integration of local environmental resources into biology instruction. Despite the ecological richness of East Nusa Tenggara's coastal ecosystems, these contexts have not been systematically incorporated into learning activities. The teacher acknowledged that available instructional materials rely heavily on textbook content and provide few opportunities for students to explore biological concepts through local environmental phenomena.

Interestingly, the findings indicate that the main challenge is not technological readiness. The school possesses adequate facilities, including internet access, projectors, and students' personal mobile devices. However, these resources have not been fully utilized to create interactive and student-centered learning environments. The teacher expressed a strong need for a digital learning resource capable of integrating project-oriented learning, contextual environmental issues, and creative thinking development within a single instructional framework. These findings suggest that the current instructional gap lies primarily in pedagogical design rather than infrastructure availability. Therefore, the development of a Coastal Ecosystem-Integrated POPBL E-Module may provide a practical solution for supporting more meaningful and creativity-oriented biology learning.

3.2 Student Needs Analysis

The questionnaire results revealed several important patterns regarding students' learning experiences, perceptions, and expectations. Overall, students demonstrated positive attitudes toward biology but reported difficulties in understanding concepts due to the limited contextualization of learning materials and the predominance of conventional instructional approaches.

Table 3. Student Needs Analysis Results

Indicator	Percentage (%)
Students perceiving biology as difficult	45
Learning connected to everyday life	45
Learning connected to coastal ecosystem contexts	40
Experience with project-based learning activities	25
Existing teaching materials considered engaging	30
Need for digital learning resources	100
Digital resources facilitate understanding	70
Support for multimedia-based learning materials	100

Nearly half of the students perceived biology as a difficult subject. This finding indicates that many learners continue to experience challenges in constructing a meaningful understanding of biological concepts. More importantly, only a limited proportion of students reported that learning activities were regularly connected to everyday life or local environmental contexts. This suggests that current instructional practices may not sufficiently support contextual learning, which is widely recognized as an important factor in promoting conceptual understanding and long-term knowledge retention.

The results also revealed a notable lack of project-based learning experiences. Only one-quarter of students reported having participated in project-oriented activities. This finding is significant because project-based learning provides opportunities for students to engage in inquiry, collaboration, problem-solving, and creative production—skills that are essential for twenty-first-century learning.

Students' responses further demonstrated a strong demand for digital learning resources. All respondents supported the development of multimedia-based instructional materials, while the majority believed that digital resources could improve their understanding of biology concepts. This finding indicates that students are not only technologically ready but also receptive to more interactive and flexible learning environments. Taken together, these results reveal a clear need for learning resources that are contextual, interactive, technology-enhanced, and capable of facilitating active student participation. Such characteristics align closely with the pedagogical principles of POPBL and support the development of an innovative e-module integrating coastal ecosystem content.

3.3 Students' Creative Thinking Skills Profile

The assessment of creative thinking skills revealed that students demonstrated low performance across all four dimensions of creativity, namely fluency, flexibility, originality, and elaboration. The consistency of these findings suggests that creativity-related competencies have not yet been optimally developed within the current instructional environment.

Table 4. Students' Creative Thinking Skills Profile

Indicator	Percentage (%)	Category
Fluency	30	Very Low
Flexibility	35	Very Low
Originality	35	Very Low
Elaboration	30	Very Low

The fluency score indicates that students experienced difficulties generating multiple ideas or alternative solutions when responding to biological problems. This finding suggests that students are rarely exposed to learning situations requiring divergent thinking and idea exploration. Similarly, the low flexibility score reflects students' limited ability to approach problems from multiple perspectives. The inability to generate diverse solutions may indicate a learning culture that prioritizes single correct answers rather than exploratory thinking processes.

The originality dimension also remained within the very low category, suggesting that students seldom produce novel or innovative responses. This pattern may be associated with instructional approaches that emphasize reproduction of knowledge rather than knowledge creation. Furthermore, the low elaboration score indicates that students experience difficulties expanding, refining, and communicating ideas in a comprehensive manner.

A particularly important finding is the uniformity of low performance across all four indicators. Rather than representing isolated weaknesses, the results suggest a broader deficiency in learning experiences that encourage exploration, inquiry, innovation, and creativity. This pattern reinforces the argument that improvements in creative thinking require systemic instructional interventions rather than isolated classroom activities.

3.4 Integrated Development Needs

The triangulation of teacher interview data, student questionnaire responses, and creative thinking assessment results revealed a coherent pattern that strongly supports the development of a Coastal Ecosystem-Integrated POPBL E-Module. Three major needs emerged from the analysis. First, teachers require instructional resources capable of facilitating student-centered learning while integrating local environmental contexts into biology education. Second, students require engaging digital learning materials that support active participation, independent learning, and meaningful connections between biological concepts and their surrounding environment. Third, the consistently low profile of creative thinking skills demonstrates the urgent need for learning interventions specifically designed to foster idea generation, problem-solving, creativity, and innovation.

Importantly, these findings are interconnected rather than independent. The limited implementation of project-based learning, minimal integration of local coastal ecosystem contexts, and reliance on conventional instructional materials appear to contribute collectively to the low level of creative thinking observed among students. This pattern indicates that improving creativity requires more than simply introducing new content; it requires a pedagogical approach that simultaneously promotes inquiry, contextual understanding, collaboration, and authentic problem-solving.

The findings, therefore, provide strong empirical justification for the development of a Coastal Ecosystem-Integrated POPBL E-Module. By combining project-oriented problem-solving activities, contextual coastal ecosystem issues, and interactive digital learning features, the proposed e-module has the potential to address the instructional gaps identified in this study while supporting the development of students' creative thinking skills. Consequently, the proposed innovation emerges not merely as an alternative instructional resource but as a contextually relevant educational response to the needs identified by both teachers and students.

Discussion

The findings of this study reveal interconnected instructional needs that provide an empirical basis for developing a coastal ecosystem-integrated Project-Oriented Problem-Based Learning (POPBL) e-module in biology education. Evidence from the teacher interview, student questionnaires, and creative thinking assessments indicates that current instructional practices provide limited opportunities for project-oriented inquiry, contextual environmental learning, and creative idea generation. These findings are consistent with the broader argument that creative thinking requires learning environments in which students actively investigate problems, explore alternative solutions, and construct knowledge rather than merely reproduce information (Dilekçi & Karatay, 2023; Ramdani et al., 2022). However, because this study employed a descriptive needs analysis rather than an experimental design, the observed learning conditions should be interpreted as potential areas for instructional improvement, not as established causes of students' low creative thinking performance.

One important finding concerns the limited implementation of student-centered and project-oriented learning. The teacher reported that instruction predominantly involved lectures and classroom discussions, while only 25% of students indicated experience with project-based activities. This suggests a gap between existing instructional practices and the opportunities for authentic

investigation and problem-solving emphasized in contemporary science education. Smith et al. (2022) identified meaningful problems, learner participation, and inquiry as important principles of problem-based learning, while Markula and Aksela (2022) highlighted the significance of project implementation in K–12 science education. Furthermore, Rizki and Suprapto (2024) examined project-oriented problem-based learning as a framework for developing higher-order thinking in science contexts. Together, these studies provide a pedagogical rationale for considering POPBL as a potential response to the instructional needs identified in the present study. Nevertheless, its suitability and effectiveness in this specific setting remain to be evaluated.

Students' creative thinking profiles provide further justification for designing learning activities that explicitly address divergent thinking. Scores for fluency (30%), flexibility (35%), originality (35%), and elaboration (30%) were classified as very low according to the study's assessment criteria. The relatively similar results across the four dimensions suggest that the identified needs are not restricted to a single aspect of creativity. Instead, instructional activities may need to provide systematic opportunities for generating multiple ideas, considering alternative perspectives, proposing original solutions, and elaborating those solutions. Affandy et al. (2024) discussed the integration of creative pedagogy into problem-based learning, while Li and Tu (2024) examined project-based learning combined with collaborative learning strategies to support creative thinking. These studies suggest that creativity-oriented learning design should extend beyond assigning projects to students; it should incorporate structured prompts, collaborative exploration, reflection, and opportunities to refine ideas. Accordingly, the proposed e-module should include tasks specifically aligned with each assessed dimension of creative thinking.

Another significant finding is students' strong preference for digital instructional resources. All 20 respondents expressed support for digital learning resources and multimedia-based materials, while 70% indicated that digital resources could facilitate their understanding of biological concepts. These responses suggest that interactive digital materials may be acceptable to the participating students, although expressed preferences do not establish their instructional effectiveness. Asrizal et al. (2023) reviewed evidence concerning the relationship between e-module use and higher-order thinking skills in science learning, while Aliyah and Widiyatmoko (2022) investigated e-module development for critical and creative thinking. Similarly, Puspita et al. (2024) conducted a needs analysis concerning interactive PBL-STEM e-modules in biology education. These studies support the relevance of developing digital resources that integrate pedagogical activities with subject content. For the present context, the proposed e-module should therefore function not merely as an electronic textbook but as a structured learning environment incorporating authentic problems, multimedia explanations, project guidance, and opportunities for reflection.

The limited integration of local coastal ecosystems represents another important instructional gap. Only 40% of students reported learning experiences connected to coastal ecosystem contexts, despite the geographical relevance of these environments to the study setting in East Nusa Tenggara. Coastal ecosystems offer opportunities to explore biodiversity, ecological interactions, environmental degradation, and conservation through problems grounded in students' surroundings. Sukri et al. (2023) investigated the integration of coastal local wisdom into problem-based learning, while Syahfitri and Muntahanah (2024) examined local wisdom-based interactive digital modules in relation to students' thinking dispositions. In addition, Makhrus et al. (2025) explored the integration of local wisdom and sustainability-oriented content into digital learning materials. These studies provide a rationale for contextualizing the proposed e-module through local environmental issues. However, the specific cultural and ecological content should be selected through further consultation with teachers and relevant local stakeholders to ensure scientific accuracy and contextual appropriateness.

The integration of the three data sources suggests several practical design priorities. First, the e-module should organize learning around authentic coastal environmental problems that require investigation and project development. Second, its activities should explicitly target fluency, flexibility, originality, and elaboration through open-ended questions, alternative solution generation, project

planning, and reflective evaluation. Third, multimedia components should support the investigation of biological phenomena rather than serve primarily decorative purposes. These priorities are consistent with the broader evidence on project-based learning and learning outcomes reported by Zhang and Ma (2023), as well as the emphasis on meaningful project implementation discussed by Cruz et al. (2022). The principal contribution of the present study is therefore the identification of context-specific design requirements, rather than evidence that the proposed e-module has already improved students' creative thinking skills.

Several limitations should be considered when interpreting these findings. The study involved one teacher and 20 students from a single school, restricting the transferability of the results to other educational settings. The needs analysis also relied partly on self-reported perceptions, which may not fully represent actual classroom practices or students' future engagement with digital materials. Moreover, the study did not develop, validate, or experimentally evaluate the proposed e-module. Future research should translate the identified requirements into a prototype, assess its content and usability with relevant experts and users, and subsequently investigate its effectiveness using an appropriate research design. Overall, the findings indicate a contextually grounded need for a coastal ecosystem-integrated POPBL e-module that combines authentic environmental inquiry, structured creative thinking activities, and interactive digital learning resources.

4. CONCLUSION

This study investigated the need for developing a Coastal Ecosystem-Integrated Project-Oriented Problem-Based Learning (POPBL) e-module to promote students' creative thinking skills in biology learning. The findings revealed a consistent pattern across teacher interviews, student questionnaires, and creative thinking assessments. Current biology instruction remains predominantly teacher-centered, with limited implementation of project-based learning, insufficient integration of local coastal ecosystem contexts, and minimal utilization of interactive digital learning resources. At the same time, students demonstrated a strong demand for contextual and technology-enhanced learning materials, while their creative thinking skills—particularly fluency, flexibility, originality, and elaboration—were found to be at a very low level.

The integrated findings provide strong empirical evidence supporting the development of a Coastal Ecosystem-Integrated POPBL e-module as a contextually relevant instructional innovation. By combining authentic coastal environmental issues, project-oriented problem-solving activities, and interactive digital learning features, the proposed e-module has the potential to support more meaningful biology learning and foster creative thinking skills. This study contributes to the growing body of research on contextual digital learning by highlighting the importance of integrating local environmental resources, student-centered pedagogy, and creativity-oriented learning design within biology education.

Nevertheless, this study has several limitations. The research involved a relatively small number of participants from a single school, which may limit the transferability of the findings to other educational contexts. In addition, the study focused on needs analysis and did not evaluate the effectiveness of the proposed e-module in improving learning outcomes or creative thinking skills. Future research is therefore recommended to develop, validate, and implement the proposed e-module on a larger scale and to examine its impact on students' creative thinking, problem-solving abilities, environmental literacy, and other twenty-first-century competencies.

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