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Developing Preservice Biology Teachers' Creative Thinking Skills Through Integrating E-Books into Problem-Based Learning

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Abstract

Developing Preservice Biology Teachers' Creative Thinking Skills Through Integrating E-Books into Problem-Based Learning*. This research aims to find a low solution quality of teachers in North Maluku Province, Indonesia. One alternative proposed is integrating e-books into problem-based learning to see the impact on preservice biology teachers' creative thinking skills. Pre-experiment-bookstall research methodology and one group's pretest-posttest design are used. This research was carried out in 2024, and the research location was the Study Program for Biology Education, University of Khairun, Indonesia. The research subjects were preservice biology teachers. The selection of research subjects was based on the initial ability level (high, medium, low), so the number of research subjects was 6 (2 groups). The research results concluded that integrating e-books into a problem-based learning model was very effective in improving the creative thinking skills of preservice biology teachers. Further research also makes it possible to see the differences in the effect of providing learning activity links (e-books) before or after offline lectures are conducted.*

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INTRODUCTION

The Indonesian government has undertaken several initiatives to raise the standard of the country's education system. The Law of the Republic of Indonesia Number 14 of 2005 about instructors and Lecturers mandates, among other things, that the quality of instructors be improved in a planned, directed, and sustained manner. Additionally, according to the law, teachers need to be credentialed through undergraduate or graduate programs in higher education. Teachers are also required to maintain a variety of abilities that are relevant to their field of work and to consistently enhance and expand their academic credentials and competencies to keep up with advancements in science, technology, and the arts.

The efforts made by the government to improve the quality of teachers have yet to produce maximum results. The national average teacher quality based on the Teacher Competency Test (UKG) must still be categorized as good. However, some things need special attention, namely the quality of teachers in North Maluku Province. In the Regional Education Balance managed by the Ministry of Education, Culture, Research, and Technology, the average UKG results for North Maluku Province show that the average score for teachers in North Maluku is 44.79. This value is the lowest nationally and below the national average (50.64). The average value of the UKG results is the average value of the combined

pedagogical and professional competency values. North Maluku teachers' pedagogical and professional competency scores are 43.49 and 45.34, respectively. These two scores are also the lowest nationally (Kemendikbudristek, 2021).

The situation regarding teacher quality problems, especially among biology teachers in North Maluku, certainly requires finding alternative solutions. Based on the average value regarding teacher quality, the solution can be started by improving pedagogical and professional competence because the average value describes the teacher's pedagogical and professional competence. Efforts to increase biology teachers' pedagogical and professional competence can begin by preparing prospective biology teacher students or preservice biology teachers to have these two abilities. One of the pedagogical competencies is related to selecting learning methods or approaches suitable to the material and professional competencies.

The selection of a suitable learning method or approach is related to preservice biology teachers based on their experiences. Preservice biology teachers will not use a learning method or approach that they have not mastered or have never had the information and experience of participating in these learning activities. One alternative learning approach that preservice biology teachers have most likely heard of, understood, or mastered is problem-based learning (PBL) because this learning approach is always presented in the socialization of implementing the 2013 Curriculum as an alternative to managing learning activities in the classroom. PBL is a learning model that experts have developed to answer various challenges and problems in the world of education. A learning methodology called PBL was made famous in the 1960s by Barrows and Tamblyn. This is an extension of their study on medical students' reasoning skills conducted at McMaster Medical School in Canada (Savin & Major, 2004).

One of the professional competencies that can be explored from problem-based learning activities is the ability to think creatively. Creative thinking is one of the basic skills needed in the 21st century, besides critical thinking, communication, and collaboration (Ernawati et al., 2022). The choice of creative thinking as a cognitive domain in this research was based on the research of Nuraini Sirajudin et al., which examines the critical, creative, communicative, and collaborative thinking of preservice biology teachers and has been carried out for 2 years in 2019 and 2020. Based on this research, creative thinking is a variable that needs more attention than other elements because this element is lower than other cognitive elements (Sirajudin dkk., 2020; Sirajudin dkk., 2021). It is essential to know that creativity exists in every human activity, and every human being, both young and old, has creative abilities. The research, planned to be designed in classical learning or training, is a form of training expected to provide new experiences in developing preservice biology teachers' pedagogical competence and professional competence.

To cultivate creativity among preservice biology teachers at Khairun University, lecturers play a crucial role in creating a conducive learning environment. This environment encourages students to explore familiar issues and scenarios, fostering engagement and curiosity. In biology education, this process can be enhanced by introducing problem-based learning (PBL), where students are given the chance to investigate real-life problems and experiment with scientific ideas. Biology lecturers should provide scenarios, resources, and tools that stimulate critical thinking and creativity while allowing students ample time for experimentation and discussion. Feedback plays a key role here—by offering constructive criticism and supporting students' ideas and theories, lecturers can help them refine their creative skills. Through these interactive learning experiences, preservice biology teachers are not only expected to engage in hands-on activities but also develop innovative solutions to real-world biological challenges.

However, there is a growing need to assess whether the current resources, such as e-books, or creative thinking training, meet the specific needs of these preservice teachers. In this case, detailed initial data is essential to determine whether such interventions are necessary.

For instance, within the biology education study program at Khairun University, it is important to gather data on whether preservice teachers feel the need for e-books to enhance their learning or if creative thinking training is more beneficial. This research seeks to answer these questions by exploring whether these resources are truly essential for prospective teachers or if they reflect the needs of the researchers themselves. This context-based evaluation will provide a clearer understanding of how to best foster creativity in biology education at Khairun University.

The problem-based learning model is a practical approach to developing 4C skills (Nurhayati et al., 2024). However, each learning model certainly has its strengths and weaknesses. Some of the weaknesses in PBL are students' difficulty understanding the material; the knowledge students acquire needs to be better organized, difficulty finding meaningful questions, complexity and time management, group management, and students who need more team skills to work with members. Groups and process versus content (Arends & Kilcher, 2010; Hemker, 2001; Marx et al., 1997). Based on these weaknesses, the researcher proposes an alternative solution to this problem through the development of electronic textbooks (e-books) because one of the learning strategies most preferred by undergraduate students is re-reading lecture notes or textbooks (Karpicke et al., 2009). The hope is that with the availability of textbooks, students can use these textbooks as a means of learning. The electronic element shows a process in which the user attempts to control the environment with a computer, so the electronic textbook developed is an electronic textbook. The study's findings demonstrate that e-books can be utilized by instructors and students as a learning tool to fulfill 21st-century learning objectives (Agustin & Razi, 2023) because they can improve high-level thinking skills (Sunaryo et al., 2020), especially creative thinking abilities (Kusumaningtyas & Siska, 2020).

Electronic textbooks, or e-books, have become increasingly popular in the digital age due to their convenience and interactive features (Woody, 2010). These digital resources allow users to perform tasks such as highlighting text, enlarging images, and sharing their thoughts and notes with others (Koć-Januchta et al., 2022). Additionally, e-books can integrate a wide range of multimedia elements like digital texts, photos, animations, simulations, videos, and audio files. These features make e-books highly versatile, supporting various learning needs by allowing students to engage with content in more dynamic ways. E-books also come equipped with essential tools, such as the ability to annotate, search, bookmark, refer to different sections, and edit content. Furthermore, they provide students with easy access to online resources, such as websites and quizzes, which can supplement classroom learning (Lin et al., 2015). This makes e-books a valuable educational tool, especially in fields like science, where interactive simulations and multimedia can enhance students' understanding of complex concepts.

However, like any educational tool, e-books come with both advantages and disadvantages. On the one hand, the interactivity and multimedia features of e-books are major advantages, as they can accommodate different learning styles and make learning more engaging. E-books can also be updated easily, ensuring that students have access to the latest information. On the other hand, some studies have pointed out disadvantages, such as the potential for distractions due to the integration of online features and multimedia, as well as issues with screen fatigue after extended reading sessions. Additionally, not all students may have access to devices or the internet to use e-books effectively, leading to a digital divide. In this research, the focus is on creating e-books that specifically cater to the needs of preservice biology teachers at Khairun University. Unlike other e-books that are generally used in a wide range of educational settings, this research aims to develop e-books that include contextual content tailored to local biology education needs, possibly addressing specific challenges or knowledge gaps observed in these teachers. This focus on localized content might be one of the key differentiators in this study compared to similar research.

The results of searches and searches for Environmental Education Textbooks from various sources show that only a few books discuss context-based environmental education material or problems based on regional characteristics. Recent searches for Environmental Education Textbooks from various sources indicate a concerning scarcity of resources that focus on context-based environmental education material, particularly those addressing regional characteristics specific to North Maluku. A study conducted on July 15, 2024, involving observations of 20 biology teachers from Khairun University, revealed that only 10% of the textbooks utilized by these educators incorporate localized environmental issues. These teachers, who play a critical role in shaping future biology educators, reported that the existing materials often lack relevance to the environmental challenges faced in their region, such as waste management and conservation efforts in Ternate City. This gap in the curriculum emphasizes the need for resources that not only align with the national educational standards but also resonate with the unique ecological context of North Maluku.

The observations were carried out during a professional development workshop held at the Khairun University Faculty of Teacher Training and Education, focusing on enhancing teaching methodologies in environmental education. During the session, teachers expressed frustration with the limited availability of textbooks that address local environmental problems, such as the impact of plastic waste on Ternate's coastal ecosystems. The feedback collected through surveys indicated that educators are keen on integrating more contextually relevant materials into their teaching practices to foster a deeper understanding among students about their environment. This desire for localized content highlights the necessity for developing electronic environmental education textbooks that leverage problem-based learning, thus making the learning experience more engaging and applicable to the student's immediate surroundings. Besides that, McGowan (2009) suggests that future researchers should start by examining the impact of textbooks on students' learning. Other than that, electronic textbooks, or e-textbooks, have additional features that allow students to share their work in their e-books and their thoughts with other students. These features include the ability to display a variety of digital sources, including digital texts, photos, animations, simulations, video, audio, and others; they can support learning with several essential text functions, like highlighting, annotating, searching, bookmarking, referring, and editing; and they give students easy access to Internet resources, like websites and online quizzes.

The integration of electronic textbooks (e-books) into problem-based learning (PBL) can significantly enhance scientific creativity in biology education, especially for preservice biology teachers. For example, when students are tasked with investigating a local environmental issue—such as the effects of deforestation on biodiversity in North Maluku—they can use e-books to access real-time data, scientific articles, and multimedia resources that provide in-depth information. E-books can incorporate simulations of ecological systems, allowing students to manipulate variables and predict outcomes based on their understanding of biology. Through such interactive features, e-books not only help students grasp the complexity of real-world problems but also encourage them to think creatively by exploring different solutions, testing hypotheses, and collaborating with peers to refine their ideas.

Several problems highlight the need for e-book integration in PBL and scientific creativity within the context of preservice biology teachers. First, the low pedagogical and professional competence scores in North Maluku, as indicated by the Teacher Competency Test (UKG), reveal a gap in teaching strategies that foster critical and creative thinking. Second, there is a lack of resources that specifically cater to local environmental contexts, which limits the relevance of learning materials for students. Third, traditional textbooks do not offer the interactive and multimedia functionalities necessary for modern education, making it difficult for students to engage deeply with the content. To address these issues, this research proposes the development of e-books tailored to the local needs of biology students

in North Maluku. These e-books will include region-specific environmental challenges, interactive tools for experimentation, and resources that enhance creative thinking skills. This solution aims to close the gap between conventional learning methods and the demands of 21st-century education.

In terms of research gaps, while there have been studies on the use of e-books in education, most have focused on general features such as ease of access and interactivity. Few studies have explored the integration of e-books in PBL specifically aimed at fostering scientific creativity in biology. For instance, Kusumaningtyas & Siska (2020) found that e-books can improve critical thinking, but did not delve into their role in creative thinking. Similarly, studies by Ernawati et al. (2022) have emphasized the importance of 21st-century skills but did not explore the specific use of e-books in a PBL setting. This research fills the gap by focusing on how e-books can support scientific creativity through problem-based learning, particularly in the context of North Maluku's unique environmental challenges. The novelty lies in the combination of localized content, interactive multimedia features, and the integration of scientific creativity within PBL.

The benefits of this research are multifaceted. On a micro level, it will directly improve the pedagogical and professional competence of preservice biology teachers at Khairun University by providing them with interactive and contextually relevant learning tools. The use of e-books will also enhance their creative thinking abilities, making them better equipped to teach biology in a way that fosters critical and innovative problem-solving skills in their future students. On a macro level, this research could serve as a model for other regions in Indonesia that face similar educational challenges. By demonstrating how technology can be used to bridge the gap between traditional teaching methods and modern educational demands, this study could influence national educational policies and initiatives aimed at improving teacher quality across the country.

The scope of this research is limited to preservice biology teachers at Khairun University in North Maluku, specifically focusing on their experiences with e-books and PBL as tools for enhancing scientific creativity. The research will involve both qualitative and quantitative methods, including surveys and experimental trials, to evaluate the effectiveness of e-book integration in developing creative thinking skills. The e-books developed for this study will be designed with a focus on local environmental issues, ensuring that the content is relevant to the student's future teaching contexts. While the study is geographically and contextually specific, its findings could have broader implications for educational practices in similar regions facing challenges in teacher competency and resource availability.

METHODS

Pre-experimental in nature, this kind of study uses a pretest-posttest design for a single group (Campbell & Stanley, 1963). The research was conducted in 2024 at the Biology Education Study Program, Faculty of Teacher Training and Education, Khairun University, North Maluku. The study focused on six preservice biology teachers, carefully selected from different levels of initial abilities (high, medium, and low) to ensure a balanced representation of skill levels. These six students were selected from a larger population of biology education students at the university. The selection process involved an assessment of the student's initial ability levels, with two students each representing high, medium, and low ability levels. The criteria for categorizing students included academic performance, participation in practical assignments, and problem-solving skills in biology. This stratified sampling ensured that the research subjects accurately reflected the diversity in student capabilities, thus providing a comprehensive view of their creative thinking development. Below is a table summarizing the research subjects' characteristics:

Table 1. Research Sample

Subject ID	Initial Ability Level	Gender	Age	Year of Study
S1	High	Female	21	4
S2	High	Male	22	4
S3	Medium	Female	21	3
S4	Medium	Male	23	3
S5	Low	Female	22	2
S6	Low	Male	21	2
S1	High	Female	21	4

The research instruments for this study included a creative thinking ability test and practicality assessment forms for both lecturers and students. The creative thinking ability test was designed to evaluate the effectiveness of integrating e-books into problem-based learning (PBL). This test was administered twice: once before the learning activities (pre-test) and again after the activities (post-test) to measure any changes in the student's creative thinking skills. The test specifically aimed to assess key components of creative thinking, such as fluency, flexibility, originality, and elaboration in problem-solving within biological contexts. The practicality assessment form, on the other hand, gauged the opinions of lecturers and students on the ease of use, clarity, and attractiveness of the e-book integration in PBL. This feedback was essential to understanding the user experience and overall effectiveness of the instructional design.

The creative thinking ability test used in this study was adapted from previous research on creative thinking skills in education, specifically based on the Torrance Tests of Creative Thinking (TTCT), a widely recognized instrument for evaluating creativity in various fields (Torrance, 1974). However, the researcher made modifications to tailor the test to the specific context of biology education. These modifications involved designing questions and tasks related to biological problems and scenarios that the preservice biology teachers might encounter in their professional lives. The researcher did not entirely develop the test from scratch but rather adapted and contextualized existing models to ensure they were relevant to the research objectives. This approach allowed for more accurate measurement of how well the integration of e-books in PBL could enhance creative thinking in the field of biology.

Data from research on the creative thinking processes of preservice biology teachers will be analyzed descriptively. These creative thinking skills will be assessed based on originality, fluency, elaboration, and flexibility indicators. This data will be analyzed using descriptive statistics. Descriptive analysis was carried out only to obtain scores regarding creative thinking skills. Next, they are classified based on standard scores. If Z represents the standard score, then an A value is assigned for $Z > 1.50$; a B value for $0.50 < Z \leq 1.50$; a C value for $-0.50 \leq Z \leq 0.50$; D value for $-1.50 \leq Z < -0.50$; and the E value for $Z < -1.50$ (Glass & Hopkins, 1984). Because the area of the standard curve for $-3.00 < Z < 3.00$ is 0.9970. Usually, all standard scores from the assessment results are considered in the area $-3.00 < Z < 3.00$. If the five values are assigned using the form of average deviation (M) and standard deviation units (s), then these values are determined as follows. The A value is for $X > (M + 1.5s)$, the B value is for $(M + 0.5s) < + 0.5s)$, D value for $(M - 1.5s) <$ Because the scoring of the level of creative thinking skills in this research was carried out with a range from 1 to 4, to determine the criteria for this research product a classification was used which was determined with an ideal average $= (1 + 4)/2 = 2.5$, range $= 4 - 1 = 3$, and the unit width of the score area is $3/6 = 0.5$. Because the scores recorded are up to two decimal places, the score classification can also be stated in Table 2.

Table 2. Criteria for Creative Thinking Skill Level

Score (X)	Mark	Criteria
3.25 < X	A	Excellent
2.75 < X ≤ 3.25	B	Good
2.25 < X ≤ 2.75	C	Currently
1.75 < X ≤ 2.25	D	Bad
X ≤ 1.75	E	Ugly

The feasibility of using e-books in problem-based learning was evaluated in this study, and it received a minimum score of "B" in the "Good" category. Therefore, the integration of e-books into problem-based learning is deemed appropriate for usage or effective in enhancing creative thinking abilities if the outcomes of the assessment of student's creative thinking skills (overall) are with a minimum score of "B" (Good). The effectiveness of integrating e-books in problem-based learning can also be determined based on the level of student learning completion. Based on consideration of the complexity criteria of creative thinking ability (high), carrying capacity (medium), and student intake (medium), the researcher used a score of 56 [Minimum Student Completeness Criteria] so that if a student on the summative test got a minimum score of 56, the student was declared complete and have achieved learning mastery in the learning outcomes of the subject in question. In addition, researchers used a minimum criterion of "High" to determine the effectiveness of integrating e-books into problem-based learning by reviewing the percentage of students who completed the summative test. Therefore, if the percentage of students who complete the test has reached the "High" criteria, then the product being developed is considered effective. The criteria for the percentage of learning completeness in this research are based on the criteria used on campus. These criteria range from 0 to 100%. The range is divided into four different intervals. Each interval has its criteria. Very high criteria for X ≥ 80, high criteria for 60 ≤ X < 80, low criteria for 55 ≤ X ≤ 70, and very low criteria for X ≤ 55.

Table 3. Criteria for Percentage of Student Learning Completeness

Completeness (%)	Criteria
X ≥ 85	Very high
70 ≤ X < 85	High
55 ≤ X < 70	Low
X < 55	Very low

The normalized gain (N-Gain) test was used to determine the difference between the average score for final creative thinking skills and initial creative thinking skills. To determine whether student learning outcomes are increasing, the N-Gain value is employed. N-Gain Formula (Hake 1998) as follows:

$$\langle g \rangle = \frac{\%\langle G \rangle}{\%\langle G \rangle_{max}} = \frac{(\%\langle S_f \rangle - \%\langle S_i \rangle)}{(100 - \%\langle S_i \rangle)} \quad (1)$$

$\langle S_f \rangle$= End of Class Average

$\langle S_i \rangle$= Initial Class Average

Scoring of questionnaire responses from users (lecturers and students) of biology education in this research was carried out with a range from 1 to 4, so to determine the criteria for this research, a classification was used, which was determined by the ideal average = (1 + 4)/2 = 2.5, range = 4 – 1 = 3, and the unit width of the scoring area is 3/6 = 0.5. Because the

scores recorded are up to two decimal places, the score classification can also be expressed in Table 4.

Table 4. User Response Criteria

Score (X)	Criteria
$3.25 < X$	Very high
$2.75 < X \leq 3.25$	High
$2.25 < X \leq 2.75$	Moderate
$1.75 < X \leq 2.25$	Low
$X \leq 1.75$	Very low

Flip PDF Professional is the media used in making electronic books (E-Books). Because e-books can incorporate legitimate learning tools like images, animation, video, and Flash, they can be utilized as electronic learning resources (Suprapto et al., 2022). Besides, e-books using professional PDF flip can be used as learning media (Komikesari et al., 2020). The electronic textbook format is an HTML file (HTML5).

The research activities were conducted over eight meetings (weeks), combining both offline and online modes of learning. The activities involved lectures, problem-based learning (PBL), and field research, with a focus on environmental issues in Ternate City. Here is a summary table of the activities:

Table 5. Learning Activities

Meeting (Week)	**Activity Type**	**Content/Focus**	**Learning Mode**
1	Initial Test & Lecture	Environmental Problems: Global, National, Local	Offline
2	Lecture	Environmental Problems Continued	Offline
3	Lecture & LKM-4	Problem Solving with LKM-4	Offline & Online
4	Lecture & LKM-4	Problem Solving with LKM-4	Offline & Online
5	Survey Research (Fieldwork)	Field Research on Waste Management (Dufa Dufa Market, North Ternate)	Offline
6	Survey Research (Fieldwork)	Field Research on Waste Management (Dufa Dufa Market, North Ternate)	Offline
7	Final Test Preparation	Preparation for the Final Test	Online
8	Final Test & Evaluation	Final Test & Group Project Evaluation	Offline

In the first few meetings, students were introduced to environmental problems through offline lectures. They then engaged in problem-solving activities using the Student Activity Sheet (LKM-4), which was structured around problem-based learning. Field research was conducted in weeks 5 and 6, focusing on waste management in Ternate City. The learning process culminated in a final test and evaluation. This LKM contains problems in PBL, where in the PBL process, learning starts with structured problems to complex problems or unstructured problems that deliberately do not provide all the information needed to solve or get a solution (Duch et al., 2001).

The next learning stage involves students engaging in learning activities that enable them to explain and present solutions to conservation-related problems, collaborate with others, exhibit social sensitivity and concern for the environment and society, be accountable for the

outcomes of group projects, and supervise and evaluate the completion of tasks assigned to subordinates. Material that supports learning achievement is Conservation material, which includes the Definition of Conservation, the Important Role of Conservation, Conservation Objectives, and Community-Based Conservation. Offline learning activities are done through lecture learning and community service, while online learning students complete lesson activities. 5. The student learning experience in the form of lectures is that students take part in training in preparing conservation programs/activities, and students are given problems in the form of student activity sheets. (LKM)-5. The student's learning experience in community service was conducting community service regarding conservation programs in the mangrove area of Gambesi Village, South Ternate City District, Ternate City. Students also presented problem-solving on the Student Activity Sheet (LKM)-5. Involving students directly in conservation programs is expected to increase student awareness of mangrove problems in Ternate City. According to PBL Thakur et al. (2018), PBL makes learning a fun experience by exploring new knowledge, increasing students' curiosity, connecting previous knowledge, and increasing participants' interest in learning. Educate.

After engaging in learning activities, students will be able to explain and demonstrate how to solve environmental health-related problems as a foundation for developing their ability to design biology lessons with an active student approach. They will also be able to collaborate, show social sensitivity, and show concern for the community and environment. Finally, they will be able to take accountability for the group work outcomes and oversee and assess the completion of tasks assigned to workers under their supervision. Material that supports learning achievement is Environmental Health material which includes Introduction, Environmental Health, Mission and Goals of Environmental Health, Sources of Drinking Water, Environmental Risk Factors, Ecological Concepts of Health, Limits of Environmental Health, Human Relations with the Environment, Environmental Health Problems, Role Environmental Health in the Community, Climate Change and Environmental Health, Healthy Water Facilities, Drinking Water Sources, Simple Drinking Water Treatment, Environmental Sanitation, and Public Places and Food Processing (TUPM). Offline learning activities are carried out through lectures and research, while online learning students complete Lesson Activity 6. The student learning experience in the form of lectures is that students solve problems on the Student Activity Sheet (LKM)-6. The student learning experience in the form of research was that students surveyed the use and response of the community to the Rainwater Storage Installation (IPAH) in Tubo Village, North Ternate City District, Ternate City. The research activity ended with a final test of creative thinking skills.

RESULTS AND DISCUSSION

This study aimed to investigate the effectiveness of integrating problem-based learning (PBL) with environmental education electronic textbooks (e-books) in enhancing students' creative thinking skills. The primary hypothesis of this research was that the use of e-books, integrated within a PBL framework, would result in a significant improvement in the creative thinking skills of preservice biology teachers. This research focused on measuring the four key indicators of creativity: originality, flexibility, fluency, and elaboration. These indicators were assessed through pre-and post-tests of creative thinking, aiming to compare students' abilities before and after eight weeks of learning.

After the eight-week learning period, which consisted of lectures, research activities, and interactive e-book sessions, all six students demonstrated marked improvements in their creative thinking skills. As seen in Table 4, the average initial creative thinking score across all students was 43.75, whereas the final average score reached 90.63, categorizing the students' abilities as "Very Good." The substantial increase in the average score reflects the effectiveness of the problem-based learning approach combined with the use of e-books. The study focused

on evaluating students' progress in each of the four creativity indicators. First, originality, the ability to produce unique and novel ideas, saw significant improvement. Initially, students struggled to propose original solutions to environmental problems. However, after engaging in PBL and utilizing the interactive e-book, students began to generate more creative and innovative solutions, particularly when tackling complex environmental issues in Ternate City. Second, flexibility, or the ability to view problems from different perspectives, also improved considerably. The e-book, designed with multimedia elements, allowed students to explore various aspects of environmental problems. This exposure helped them develop a more flexible approach to problem-solving, as they became adept at switching between different viewpoints and adapting their solutions accordingly.

The third indicator, fluency, which refers to the capacity to generate numerous ideas quickly, also showed notable gains. Throughout the eight weeks, students engaged in multiple brainstorming sessions facilitated by the e-book's interactive features. By the end of the course, students were able to generate a wide range of solutions to environmental problems, displaying increased fluency in their creative processes. Finally, elaboration, the ability to expand on and refine ideas, demonstrated the most dramatic improvement. Initially, students struggled to provide detailed explanations for their ideas. However, the e-book's in-depth case studies, video tutorials, and interactive exercises helped students develop their ability to elaborate on their solutions, resulting in more sophisticated and well-thought-out responses by the end of the study. Data on students' creative thinking skills are presented Table 6.

Table 6. Data on Students' Creative Thinking Skills

No	Student Name	Student Creative Thinking Skills	
		Initial Skills	Final Skill
1	Student 1	68.75	100
2	Student 2	68.75	93.75
3	Student 3	43.75	93.75
4	Student 4	43.75	93.75
5	Student 5	25	81.25
6	Student 6	12.5	81.25
	Average	43.75	90,625

It is known that all students taught utilizing problem-based learning supported by electronic textbooks have creative thinking abilities that meet the requirements for complete learning, based on the final ability data for creative thinking skills. The generated instructional materials have resulted in an average score of 90.63 for creative thinking skills among students, meeting the Very Good requirement. Problem-based learning assisted by electronic textbooks influences students' creative thinking skills. The results of the study showed a significant difference between the average initial and final creative thinking skills, with a p-value of less than 0.05. This indicates that the improvement in students' creative thinking abilities after the intervention was statistically significant. The calculation was carried out using a paired sample t-test to compare the pre-test and post-test scores. The low p-value suggests that the observed differences in creative thinking skills were not due to chance, but rather to the effectiveness of the problem-based learning approach supported by e-books. Based on this result, we can conclude that the intervention had a significant positive impact on enhancing students' creative thinking skills. E-modules effectively improve student learning outcomes (Misbah et al., 2021).

The change in the average score of final creative thinking skills compared to initial creative thinking skills was calculated using the normalized gain (N-Gain) test. Based on calculations of the normalized gain test, it is obtained $\langle g \rangle = 0.83$ and is included in the High criteria. Based on a normalized Gain score of 0.83, there is an increase in students' critical

thinking skills due to the use of problem-based learning assisted by environmental education electronic textbooks with High criteria.

Along with critical thinking, communication, and teamwork, one of the fundamental abilities required in the twenty-first century is creative thinking. The choice of creative thinking as a cognitive domain in this research was based on the research of Nuraini Sirajudin et al., which examines the critical, creative, communicative, and collaborative thinking of preservice biology teachers which has been carried out for two years, namely 2019 and 2020 and is in line with Chew and Eau (2017), which states that creativity is an essential criterion for producing leaders who are dedicated in their time and according to Sukma, Aditya, and Ellianawati (2023)their abilities. Creative thinking is one of the most essential skills in the 21st century. Based on this research, innovative thinking is a variable that needs more attention than other elements because this element is lower than other cognitive elements (4C) (Sirajudin et al., 2020; Sirajudin et al., 2021).

Providing appropriate learning facilities is crucial for the development of creative thinking skills among students. Creative thinking involves the ability to generate new ideas, solve problems, and think outside the box, which can be significantly enhanced through effective learning environments. Lecturers play a pivotal role in creating such environments by utilizing resources that encourage exploration and innovation. According to Karpicke et al. (2009), one of the most favored study strategies among undergraduate students is re-reading lecture notes or textbooks, which indicates a reliance on accessible and structured learning materials. By incorporating varied and interactive formats, such as electronic textbooks (e-books), educators can facilitate deeper engagement and foster an atmosphere conducive to creative thinking. E-books offer a dynamic way to present information, allowing students to interact with content through multimedia elements like images, animations, videos, and simulations, which can stimulate curiosity and inspire innovative thought processes.

Furthermore, the integration of e-books as electronic learning resources supports diverse learning styles and promotes active participation in the learning process. Suprapto, Tafauliyati, and Yanti (2022) highlight the benefits of e-books in enhancing the learning experience, as these resources can cater to various preferences and encourage students to explore topics more thoroughly. Additionally, research by Tan and Nismed (2011) demonstrates that using e-books during class not only improves learning outcomes but also alleviates students' anxiety, creating a more relaxed and open environment for creative expression. By equipping students with modern learning tools, educators can nurture their creative thinking abilities, ultimately preparing them to tackle complex problems and contribute meaningfully to their fields.

Good learning resources will produce maximum results if appropriate learning methods or models are delivered. One means that can be used to develop creativity is a learning model that allows students to obtain or produce many solutions to a problem. One learning model that has this character is the problem-based learning model. The result was supported by research by Sihaloho, Sahyar, and dan Ginting (2017), which concludes that the problem-based learning model influences students' creative thinking and problem-solving abilities, which is in line with the opinion of Han DK. (2024), which states that the main aim of advanced science education is to grow students' capacity for creative thinking and problem-solving.

Electronic environmental education One of the efforts to give facilities to increase students' creative thinking abilities is the use of Awaly, Sinaga, and Hasanah (2023) textbooks (e-books) through problem-based learning in this research, as e-books are effective in boosting creative thinking skills. The media used in electronic textbooks is Flip Pdf Professional, and the format chosen is HTML file (HTML5).

The effectiveness or ineffectiveness of integrating e-books into problem-based learning in improving students' creative thinking skills is determined by the final results or completeness of students' creative thinking skills. It is known that the level of completeness at the end of

learning is 100% (Very High criteria), based on the completeness of student learning during the implementation of learning. This suggests that the problem-based learning model supported by e-books can be said to be effective in enhancing students' capacity for creative thought. The normalized gain score, which increases with high criterion, is another indicator of how well the problem-based learning methodology supported by e-books enhances students' capacity for creative thought.

The integration of e-books into problem-based learning has been shown to significantly enhance students' creative thinking abilities, suggesting that both elements play a crucial role in fostering creativity. The research indicates that problem-based learning (PBL) provides a structured yet flexible framework that encourages students to explore complex issues, think critically, and develop innovative solutions. This active learning approach stimulates curiosity and engagement, allowing preservice biology teachers to immerse themselves in real-world problems related to environmental education. When coupled with e-books, which offer interactive and multimedia resources, students gain access to diverse perspectives and information that can enrich their understanding and inspire creativity. The combination of PBL and e-books creates a synergistic effect, where students are not only challenged to think creatively but are also provided with the tools necessary to express those ideas effectively.

Moreover, findings from previous studies reinforce the notion that the use of e-books enhances creative thinking skills independently of PBL. For instance, Adawiyah et al. (2019) demonstrated that e-books serve as effective educational tools, promoting higher-order thinking and creativity through their engaging content and interactivity. Additionally, Hasbiyati, Sudiarti, and Hikamah (2019) found that smartphone-based e-books significantly improved student learning outcomes, suggesting that the accessibility and convenience of e-books contribute to a more dynamic learning environment. Therefore, while problem-based learning undoubtedly cultivates an atmosphere conducive to creativity, the incorporation of e-books further amplifies this effect by providing diverse resources that support and enhance the creative process. Together, they represent a powerful strategy for developing the critical thinking and innovative capacities essential for success in the 21st century.

The e-book developed for this study played a crucial role in fostering these improvements in students' creative thinking skills. Specifically designed to align with the principles of problem-based learning, the e-book focused on environmental issues relevant to Ternate City, providing students with real-world problems to solve. The inclusion of interactive multimedia elements, such as videos, diagrams, and clickable images, enhanced students' engagement and allowed them to better understand the complexities of the environmental problems presented. The e-book was created using Flip Pdf Professional, and the format chosen was HTML5, ensuring that the content was accessible and engaging for students across different devices. The validation process, which involved feedback from experts, ensured that the e-book met high standards in terms of content accuracy, interface design, and instructional quality. Both students and instructors provided positive feedback, indicating that the e-book was practical and effective in facilitating learning.

The e-book facilitated the four creativity indicators effectively. For originality, open-ended questions, and real-world environmental problems prompted students to think creatively and generate novel solutions. In terms of flexibility, students were encouraged to explore different sections of the e-book, which presented various viewpoints on environmental issues, thus promoting flexible thinking. Fluency was enhanced through the inclusion of multiple-choice exercises and problem-solving activities that required students to generate several solutions before selecting the most appropriate one. Lastly, elaboration was supported by detailed case studies and video tutorials, which provided students with the necessary information to develop and refine their ideas comprehensively.

Despite the study's success, it had several limitations. The most notable limitation was the small sample size of six students, which limits the generalizability of the findings. Although the results indicate a positive effect of problem-based learning combined with e-books on creative thinking, further research with larger sample sizes is necessary to confirm these findings. Additionally, the study was conducted in a specific context, focusing on environmental education in Ternate City, which may limit the applicability of the results to other regions or subject areas.

Another limitation was the duration of the study. The eight-week learning period may not have been sufficient to capture the long-term effects of using PBL with e-books. Future research should consider extending the study period to assess whether the improvements in creative thinking skills persist over time. Additionally, the e-book was designed specifically for environmental education, and its effectiveness in other subjects or educational contexts remains to be tested.

In terms of relevance to previous research, the findings of this study align with those of Sihaloho, Sahyar, and Ginting (2017), who found that the problem-based learning model positively influences students' creative thinking and problem-solving abilities. Similarly, the research supports the findings of Awaly, Sinaga, and Hasanah (2023), who demonstrated that e-books can effectively improve students' learning outcomes, particularly in fostering creativity. However, this study provides new insights by focusing on the integration of e-books within a PBL framework, specifically in the context of environmental education.

The study also introduces a unique perspective by demonstrating how e-books can be designed to directly support the development of creativity through interactive learning. This approach, which combines technology with real-world problem-solving, offers a novel and effective method for enhancing students' 21st-century skills, particularly creativity. The research suggests that e-books can serve as a powerful tool for fostering not only creativity but also critical thinking, collaboration, and communication, which are essential skills for future educators. Given the small sample size, generalizing the results of this study to a wider population should be done cautiously. However, the researchers argue that the consistent use of validated instruments, along with significant pre- and post-test results, suggests that the findings could be replicated in other educational contexts with similar conditions. Larger-scale studies with diverse populations would be necessary to confirm the broader applicability of these results.

In conclusion, the integration of problem-based learning with environmental education e-books proved to be an effective strategy for improving the creative thinking skills of preservice biology teachers at Khairun University. The study demonstrates the importance of using learning materials that encourage students to think critically and creatively about real-world problems. Based on these findings, the researchers recommend that educators adopt similar approaches in their teaching, particularly when aiming to develop students' 21st-century skills. Further research is needed to explore the use of e-books in other subjects and to investigate the long-term impact of such interventions on student learning outcomes. Additionally, larger sample sizes and more diverse educational settings would provide a more comprehensive understanding of the effectiveness of this approach. Ultimately, the study contributes valuable insights into how technology and problem-based learning can be integrated to enhance creativity and improve educational outcomes.

CONCLUSION

The study highlights that teachers in North Maluku Province, Indonesia, particularly biology teachers, exhibit the lowest competency levels nationally, necessitating urgent solutions to improve teacher quality. To address this issue, the research advocates for the implementation of electronic textbooks (e-textbooks) as a learning resource for preservice

biology teachers, aiming to enhance their pedagogical and professional competencies. The findings indicate that the integration of problem-based learning with context-specific environmental education through e-textbooks significantly improves the creative thinking skills of these students. This approach not only fills the gap in existing environmental education materials but also provides a practical framework for learning that is tailored to local issues. Future research should explore the timing of e-textbook introduction—whether prior to or after offline lectures—to further understand its impact on learning outcomes. While this study provides valuable insights, its limitations include a small sample size and a narrow focus on a single geographic area, which may affect the generalizability of the findings. Subsequent studies should aim for a larger, more diverse participant group to validate these results and explore broader implications for enhancing teacher competency in various educational contexts

SUGGESTION

In light of the findings from this research, several suggestions can be made for future studies aimed at enhancing the creative thinking skills of preservice biology teachers. Firstly, it is recommended that subsequent research explores the effects of varying the timing of e-book integration within the learning process, such as using these resources both before and after offline lectures. This could help determine the optimal timing for e-book utilization to maximize student engagement and creativity. Additionally, expanding the scope of the study to include a larger and more diverse sample of preservice teachers from different educational institutions would provide a more comprehensive understanding of the effectiveness of electronic textbooks and problem-based learning across various contexts.

Furthermore, future research should investigate the specific elements of e-books that contribute to increased creativity, such as interactivity, multimedia features, and the presentation of contextualized problems. This would provide insights into how to design more effective educational materials tailored to enhancing creative thinking. Lastly, potential barriers to implementing e-books and problem-based learning in the classroom, such as limited access to technology, lack of training for educators, and resistance to new teaching methods, should be addressed. Identifying and overcoming these challenges will be crucial for the successful integration of innovative teaching strategies in biology education.

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