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A Systematic Literature Review: E-Modules Based on Project-Based Learning to Enhance Students' Learning Creativity and Critical Thinking Skills

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ABSTRACT

This study aims to analyze the contribution of e-modules based on Project-Based Learning to enhance students' learning creativity and critical thinking skills in science learning. The method used is a Systematic Literature Review of national and international articles from 2020 to 2025 obtained through Google Scholar. Based on inclusion and exclusion criteria, 19 articles were selected for analysis in terms of product validity, feasibility of use, e-module characteristics, and effectiveness on learning outcomes. The results showed that E-modules based on Project-Based Learning were considered valid to highly valid by experts, practical for use in the classroom, and capable of increasing students' creativity, participation, motivation, and critical thinking skills at a moderate to high level. The integration of contextual project activities made learning more meaningful, collaborative, and in line with the demands of the Merdeka Curriculum and the strengthening of 21st-century competencies. Theoretically, this study confirms that the combination of digital technology and the Project-Based Learning approach contributes to the development of educational science, particularly in the innovation of e-module-based science teaching materials oriented towards higher-order thinking skills. Thus, E-modules based on Project-Based Learning are recommended as an alternative innovative learning medium that supports the improvement of the quality of the learning process and outcomes for students.

Keywords*: *systematic literature review, e-modules, project based learning, learning creativity, critical thinking skills

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INTRODUCTION

This study aims to determine the contribution of e-modules based on Project-Based Learning in learning to enhance students' learning creativity and critical thinking skills. In addition, this study also examines the characteristics, feasibility, and effectiveness of e-modules based on Project-Based Learning in enhancing the quality of the learning process. It is hoped that through the application of e-modules based on Project-Based Learning, Natural Sciences (IPA) learning will become more meaningful, contextual, and able to encourage active student involvement in building 21st century knowledge and skills (Yuliana & Pangastuti, 2024).

The Merdeka Curriculum emphasizes a balance between soft skills and hard skills through student-centered learning based on real-world experiences. Project-Based Learning is considered to be in line with the principles of the Merdeka Curriculum because it provides space for the development of creativity, critical thinking, collaboration, and independent learning. The integration of digital technology through e-modules further strengthens the effectiveness of Project-Based Learning, as students can access materials flexibly, interactively, and independently (Nardi Ardana, 2023; Rahmawati, 2023). However, in practice, science learning in schools still tends to be teacher-centered and emphasizes memorization of concepts, so that students are not sufficiently facilitated in developing higher-order thinking skills, creativity, and problem-solving abilities (Mamay, 2025). In fact, ideal science learning encourages students to carry out scientific processes through observation, experimentation, reasoning, communication, and reflection. International

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studies also show that Indonesian students' science literacy and critical thinking skills still need to be improved (Hamzah et al., 2023).

Project-Based Learning involves students in completing real-world projects relevant to everyday life, encouraging collaboration, solution design, idea communication, and reflection on results. Research shows that Project-Based Learning enhances students' creativity and critical thinking skills through the integration of cross-disciplinary knowledge (Amanda et al., 2025). Active involvement in projects, such as the creation of simple biotechnology products, increases learning motivation and a more meaningful understanding of concepts, while also supporting 21st-century skills, namely critical thinking, creativity, collaboration, and communication (Nazwari et al., 2025).

Science e-modules developed with a Project-Based Learning approach can contribute positively to enhance elementary school students' learning outcomes and thinking skills. The application of these e-modules makes students more active in exploring problems, working systematically in completing projects, and reflecting on their learning process. After using the e-modules, students' ability to understand material, solve problems, and convey ideas improved. In addition, the variation in learning outcomes among students tends to decrease, making learning more equitable. These findings confirm that e-modules based on Project-Based Learning are worthy of being utilized as innovative learning media that are relevant to the demands of 21st-century learning (Desmaliza et al., 2025).

However, the effectiveness of e-modules based on Project-Based Learning is still influenced by the quality of media design, teacher and student readiness, and learning facility support. Therefore, this study is important to provide a comprehensive overview of the implementation of e-modules based on Project-Based Learning in science learning and their contribution to the development of students' creativity and critical thinking skills (Yuliana & Pangastuti, 2024).

Based on the results of the study, e-modules based on Project-Based Learning have great potential to improve the quality of science learning because they encourage students to be more active, creative, and trained in critical thinking in line with the Merdeka Curriculum. Learning becomes more contextual and interactive through the implementation of structured projects. However, the success of its application still depends on the design of the e-module, the readiness of educators and students, and the availability of supporting facilities. With good management, PjBL e-modules are suitable for use as an alternative learning medium in the 21st century.

LITERATURE REVIEW

Learning creativity is an intellectual ability that enables individuals to generate new ideas, concepts, or products that are original, useful, and relevant to the context of the problems faced. Creativity does not only come from internal potential, but is also influenced by stimuli, pressure, and learning situations that encourage students to think broadly and flexibly. According to Guilford (1973), learning creativity is evident in students' ability to generate many ideas (fluency), find various alternative solutions (flexibility), come up with unique ideas (originality), and develop ideas in detail (elaboration). In other words, creativity is also reflected in the ability to relate concepts to real situations and create innovative problem-solving. Learning creativity includes a combination of thinking skills, attitudes, experiences, and active mental activities during the learning process (Syifa' & Rohman, 2023) In science learning, creativity is important for building conceptual understanding through exploration, discovery, and scientific idea development.

In addition to creativity, critical thinking skills are also an important component of 21st-century competencies that must be developed through learning. Critical thinking is a high-level cognitive ability to analyze, evaluate, and conclude information logically and responsibly. Individuals who think critically are able to question information, identify biases or errors in reasoning, and draw rational conclusions. In learning, critical thinking includes interpretation, analysis, inference, evaluation, explanation, and self-regulation of one's own thinking process. According to Ennis (1985), this skill includes five main aspects: elementary clarification, basic support, inference, advanced clarification, and strategy and tactics (Ayun et al., 2020).

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With these abilities, students do not just passively receive information, but can assess and process information before making decisions. In science learning, critical thinking skills are very important because they require students to test evidence, analyze data, and draw conclusions based on the scientific process.

Advances in educational technology provide opportunities to enhance creativity and critical thinking through the use of e-modules as digital teaching materials. E-modules are systematically designed with a clear learning structure, equipped with learning objectives, materials, activities, exercises, feedback, and evaluation components. The advantages of e-modules lie in their flexibility of access, independent learning, and integration of multimedia such as text, images, videos, audio, and animations, which make learning more interactive and interesting (Churiyah et al., 2020). In addition, e-modules can also facilitate independent learning because students can learn at their own pace and according to their individual needs. The integration of interactive features such as quizzes, reflections, and digital projects allows e-modules to serve not only as a source of information but also as a means of developing higher-order thinking skills (Lastri, 2023). However, the effectiveness of e-modules is still greatly influenced by the quality of instructional design and the appropriateness of the learning strategies used.

One approach that is suited to the characteristics of e-modules is Project-Based Learning. Project-Based Learning is a learning model that begins with real-world problems to be solved through systematic project activities. In this model, students are involved in the process of designing, investigating, analyzing, collaborating, communicating ideas, and producing specific products as a result of learning. Through contextual projects, students are encouraged to connect science concepts with everyday life, making learning more meaningful. A number of studies show that Project-Based Learning plays a role in increasing learning motivation, creativity, active engagement, critical thinking skills, and students' understanding of concepts (Ayun et al., 2020; Churiyah et al., 2020). The collaborative process in Project-Based Learning also trains communication skills, cooperation, decision making, and responsibility for learning outcomes.

Thus, integrating Project-Based Learning into digital e-modules provides added value because project steps can be presented systematically, starting from problem identification, planning, implementation, product development, presentation, to reflection and evaluation. E-modules enable the presentation of clear, structured, and easily accessible project guidelines, so that students can follow the learning flow independently or in groups. In addition, the use of multimedia in e-modules helps clarify abstract concepts in science and provides space for students' creative exploration. 21st-century learning emphasizes not only mastery of material, but also the development of students' creativity and critical thinking skills. Project-Based Learning e-modules are considered relevant and have the potential to be developed in science learning. The combination of digital technology and Project-Based Learning is believed to be capable of creating a more interactive, participatory, contextual, and meaningful learning experience, while also supporting the development of students' creativity and critical thinking skills in the digital age.

METHOD

This study uses a Systematic Literature Review (SLR) approach to examine literature related to science education, particularly that related to the development of creativity and critical thinking skills. The SLR method was chosen because it allows researchers to synthesize previous research findings in a systematic, objective, and transparent manner. The research process was conducted online through access to various international and national journal databases, namely Google Scholar. The research was conducted from September to December 2025. The SLR procedure in this study followed the following steps:

1. Formulation of Research Questions

Focus on the benefits of using e-modules based on Project-Based Learning in learning to enhance students' learning creativity and critical thinking skills. In addition, this study also examined the characteristics, feasibility, and effectiveness of e-modules based on Project-Based Learning in enhancing the quality of the learning process.

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2. Literature search

The search was conducted using relevant keywords and following predetermined inclusion and exclusion criteria. Inclusion criteria were: journal articles, proceedings, and research reports from 2020–2025, in English or Indonesian, discussing the contribution of e-modules based on Project-Based Learning to improving students' learning creativity and critical thinking skills. In addition, it also examined the characteristics, feasibility, and effectiveness in improving the quality of the learning process. Exclusions included: irrelevant articles, theoretical articles without empirical data, or articles that did not discuss Project-Based Learning/e-modules.

3. Article Selection

Articles found in the previous stage were selected based on inclusion and exclusion criteria. Relevant articles were selected for further review. A search of the Google Scholar database yielded 1,490 articles related to the contribution of e-modules based on Project-Based Learning to improving student learning creativity and critical thinking skills, which were then filtered down to 19 eligible articles.

4. Study Quality Assessment

The methodology and reliability of the selected studies were critically evaluated to determine their strengths and limitations.

5. Data Analysis and Synthesis

Data from the articles were analyzed and synthesized systematically. Relevant findings were classified and synthesized to build a comprehensive understanding. Each article was assessed based on the following criteria:

a. QA1: Has the reference article been published in a national or international journal?
b. QA2: Is the research described in the article relevant to the topic of this study?
c. QA3: Does the reference article use research methods relevant to the development of e-modules based on project-based learning, learning creativity, and critical thinking skills?
d. The assessment was carried out using the symbols “yes” (√) or “no” (-).
e. Interpretation and Report Compilation
f. The results of the analysis are interpreted and compiled into a concise, clear, and systematic report.

RESULTS AND DISCUSSION

This study reviews various literature to identify the contribution of e-modules based on Project-Based Learning to enhance students' learning creativity and critical thinking skills, while also examining their characteristics, feasibility, and effectiveness in improving the quality of learning. The assessment of the quality of the literature used as study material is shown in Table 1.

Table 1. Assessment of Literature Quality

No	Year	Authors	Research Variables	QA1	QA2	QA3	Conclusion
1	2023	Amalia, Z., Yulianti, D., Rohman, F., & Nurhanurawati, N.	Development of Project-Based Learning E-Modules to Improve Critical Thinking Skills of Fifth Grade Students	√	√	√	√
2	2025	Andriani, P. M. F. & Juliani, R.	Development of Project-Based Interactive E-Modules to Enhance Creativity in Grade XI Students in Thermodynamics.	√	√	√	√
3	2025	Buluma, Alfred Namata, Cotrida Atugonza, Rose	Effect of In-Service Training on Teachers’ Effective Facilitation of Planning Students’ Project-Based Learning Activities	√	√	√	√

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4	2020	Cahyani, A. E. M., Mayasari, T., & Sasono, M.	The effectiveness of stem-integrated Project-Based Learning e-modules on the creativity of vocational high school students.	√	√	√	√
5	2025	Desmaliza, W., Alfiriani, A., & Rahmadianti, D.	Development of Project-Based Learning E-modules on Plants and Photosynthesis for Fourth Grade Elementary School Students.	√	√	√	√
6	2024	Firdausia, L., Nisa, A. F., Zulfiati, H. M., & Bariyah, I. Q.	The Application of Project-Based Learning-Based Ecoprint Flipbook E-Modules to Improve Student Motivation and Creativity.	√	√	√	√
7	2024	Fitriani, I., Hidayat, S., & Genisa, M. U.	Analysis of the need to develop PjBL-based e-learning modules integrated with ethnoecology to improve critical and creative thinking skills in environmental change.	√	√	√	√
8	2025	IS, E. U. K., Nurtjahyani, S. D., & Pangabean, C. I. T.	Development of a Project-Based Learning Teaching Module to Enhance Students' Science Process Skills and Critical Thinking Skills	√	√	√	√
9	2020	Jessica DeMink-Carthew & Mark W. Olofson	Hands-Joined Learning as a Framework for Personalizing Project-Based Learning in a Middle Grades Classroom: An Exploratory Study	√	√	√	√
10	2025	Mamay, A	The Effect of the Project-Based Learning Model on Enhancing Students' Creativity in the IPAS Subject on Environmental Pollution in Elementary School.	√	√	√	√
11	2023	Maulita, P. P., Hidayat, O. S., & Hasanah, U.	Needs Analysis of a Project-Based Learning E-Module in Science Instruction to Enhance the Critical Thinking Skills of Fifth-Grade Elementary School Students.	√	√	√	√
12	2022	Mustika, J	Development of a Project-Based Learning Mathematics E-Module Viewed from Students' Creative Thinking Ability.	√	√	√	√
13	2025	Mutia, T., Suharto, Y., Sahrina, A., Wahyudi, A., Atmaja, M. A. R., & Aprilia	The Effectiveness of a Project-Based Learning–Based Interactive E-Module on Students' Creative Thinking Skills.	√	√	√	√

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14	2025	Nurahmania, T. N. T., & Wardatunnissa	Development of a Project-Based Learning-Oriented IPAS E-Module to Enhance Students' Critical Thinking Skills.	√	√	√	√
15	2025	Purwanto, A., Jampel, I. N., Agustini, K., Sudatha, I. G. W., & Arimbawa, G. P. A.	Effects of Project-Based Blended Learning with E-Modules on Creative Thinking and Social Attitudes Moderated by Digital Literacy.	√	√	√	√
16	2025	Rahmani, Z., & Hikmawan	Development of an Interactive E-Module in Mathematics to Enhance the Critical Thinking Skills of Elementary School Students.	√	√	√	√
17	2025	Sari, S. N., & Cacik, S	The Feasibility of a Project-Based and Scientific Approach E-Module to Enhance Students' Creative Thinking Skills.	√	√	√	√
18	2024	Sari, W. R., Prayitno, B. A., & Sarwanto	Development of a PjBL–STEM-Based E-Module to Enhance the Critical and Creative Thinking Skills of Tenth-Grade Vocational High School Students in the IPAS Project Unit.	√	√	√	√
19	2022	Sriwindari, W., Asih, T., & Noor	Development of a Project-Based Learning (PjBL) E-Module on Waste Recycling to Develop the Creative Thinking Skills of Tenth-Grade Senior High School Students.	√	√	√	√

Overall, the journal review shows that the development and implementation of e-modules based on Project-Based Learning at various levels of education has a positive impact on the learning process and outcomes of students. These e-modules are able to improve critical thinking skills, creativity, motivation, and independent learning through contextual and collaborative project activities. Learning becomes more interactive and meaningful because students are directly involved in solving real problems, in line with the demands of 21st-century learning and the Merdeka Curriculum.

The research population in these journals includes elementary school, junior high school, high school, and vocational school students, as well as university students, with samples varying from one test class to several classes divided into experimental and control groups. Most studies use the Research and Development (R&D) method with the ADDIE, 4D, or Dick and Carey models, as well as quasi-experiments to test product effectiveness. The instruments used include expert validation sheets for material, language, and media; teacher and student response questionnaires; practicality observation sheets; learning outcome tests; and N-gain analysis or t-tests to measure improvements in students' critical thinking and creativity skills.

The reviewed journal reported that most e-modules were found to have good teaching material characteristics based on expert assessments, with categories ranging from valid to highly valid in terms of content, language, media, and pedagogy. The developed products were also deemed feasible and practical for use in learning based on practicality tests conducted by teachers and students. In terms of effectiveness, most studies reported moderate to high improvements in critical and creative thinking skills, with some even

showing large effect sizes, proving that the use of Project-Based Learning e-modules is effective in supporting student competency achievement.

Data analysis in these journals used statistical techniques such as N-gain, t-test, Cohen's d, as well as quantitative and qualitative descriptive analysis. The results of the study showed a significant difference between classes that used e-modules based on Project-Based Learning and those that did not. N-gain values were generally in the moderate to high category, while the effect size in several studies showed a strong influence. In addition, expert validation scores and user responses were in the good to very good category. These findings confirm that e-modules based on Project-Based Learning are feasible and effective for use in science learning, especially for enhancing students' learning creativity and critical thinking skills.

CONCLUSIONS AND RECOMMENDATION

Based on the overall review, it can be concluded that e-modules based on Project-Based Learning are feasible and effective as innovative teaching materials to improve students' critical thinking skills, learning creativity, motivation, and learning independence. The development of e-modules should still go through a validation and trial phase before being implemented widely. Further research is also recommended to expand the scope of subjects and integrate other approaches such as STEM, ethnoscience, ethnoecology, or Problem-Based Learning. Future development of e-modules should strengthen aspects of interactivity, multimedia completeness such as supporting images and videos, literacy, online discussions, online assessments, contextual worksheets, and virtual laboratories, and be supported by comprehensive data processing so that their feasibility and effectiveness can be optimally measured, ensuring that the modules are ready for widespread use and have a positive impact on the learning process.

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