

Development of a Problem-Based Learning E-Module on the Human Respiratory System to Enhance Critical Thinking Skills

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Abstract

The 21st-century learning paradigm demands the integration of digital resources and higher-order thinking skills, particularly critical thinking. However, preliminary observations at UPT SMPN 4 Tuban revealed that eighth-grade students exhibited low critical thinking abilities, and teachers lacked digital learning resources on the human respiratory system. This study aims to develop and validate a Problem-Based Learning (PBL)-based e-module on the human respiratory system to enhance students' critical thinking skills. This research employed the Research and Development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), limited to the Development stage due to time constraints. The e-module was designed using the Canva application, incorporating PBL syntax (problem orientation, student organization, investigation guidance, artifact development, and analysis/evaluation) and six critical thinking indicators. The validation instrument employed a Likert scale questionnaire assessed by three validators: two biology education lecturers and one junior high school science teacher. Data were analyzed using descriptive quantitative and qualitative techniques. The validation results demonstrated an overall average percentage of 88.37%, categorized as "valid." Specifically, the material feasibility aspect scored 88.47% (valid), the language feasibility aspect scored 89.33% (valid), and the media feasibility aspect scored 87.33% (valid). This research contributes a valid PBL-based e-module specifically designed for junior high school biology content. Further research is recommended to assess the e-module's practicality and effectiveness in actual classroom settings.

Keyword: : E-Module, Problem-Based Learning, Human Respiratory System, Critical Thinking, Validity

1. Introduction

The rapid advancement of 21st-century technology has fundamentally transformed the educational landscape, requiring students to possess higher-order thinking skills as core competencies for academic and professional success (Almaas et al., 2025; Roza et al., 2023). Among these competencies, critical thinking is paramount, as it enables students to analyze information systematically, evaluate arguments logically, and make reasoned decisions based on evidence rather than assumptions (Santosa, 2024). Critical thinking refers to a person's ability to develop and explain arguments from data made into complex decisions or ideas (Ennis, 2016; Suwono et al., 2023). Facione (1990) identified six core critical thinking skills: interpretation, analysis, evaluation, inference, explanation, and self-regulation.

The Indonesian educational context, particularly within the Merdeka Curriculum framework, emphasizes the development of critical thinking skills across all subjects, including Natural Sciences (IPA) (Amanda et al., 2024). The human respiratory system is fundamental biological material that directly relates to daily life and health, making it an appropriate context for developing critical thinking skills (Kartini et al., 2021; Rizqiyah & Hariani, 2025). However, preliminary observations at UPT SMPN 4 Tuban revealed significant challenges: students demonstrated low critical thinking abilities, struggled to

comprehend abstract concepts, and showed limited engagement during science lessons. Furthermore, teachers predominantly relied on conventional teaching methods with minimal utilization of digital learning resources (Dewi et al., 2023).

Learning resources play a crucial role in achieving educational objectives. E-modules are learning media designed to assist students in discovering and solving problems independently, practically, and flexibly (Nurrobi, 2024; Wulandari et al., 2021). When designed effectively, e-modules can present material systematically with multimedia elements (images, animations, audio, video) that enhance student motivation and comprehension (Laili et al., 2019; Mutmainnah et al., 2021). However, existing e-modules often contain only text and basic exercises without stimulating critical thinking activities or problem-solving scenarios (Mahardika et al., 2021; Putri et al., 2022).

The integration of appropriate learning models within e-modules can address this gap. Problem-Based Learning (PBL) is a teaching model that applies real-life issues as content to help students engage in critical thinking and problem-solving skills, and to gain essential concepts and knowledge from the subject matter (Handayani & Mudlofir, 2024; Simamora, 2021). PBL has proven effective in promoting critical thinking by requiring students to identify problems, formulate hypotheses, gather and analyze data, and draw conclusions (Mallu et al., 2023; Pratiwi & Mawardi, 2022). Meta-analyses have shown that the PBL model effectively improves students' critical thinking, problem-solving, and cognitive aspects with a high effect size (Santosa, 2024; Roza et al., 2023). Research trends also indicate a rise in publications addressing various facets of critical thinking abilities within PBL contexts (Almaas et al., 2025; Sulaiman & Azizah, 2020).

Research on e-module development trends in SINTA-indexed journals shows that the ADDIE model is the most commonly used development model, with feasibility and effectiveness being the main criteria for product quality (Nurrobi, 2024; Rahmawati & Ramadhan, 2025). E-modules that integrate 4C skills (Critical thinking, Creative thinking, Communication, and Collaboration) have been shown to be valid, practical, and effective in improving student competencies (Rohmah, 2024; Sartika et al., 2024). Given these findings, this study aims to: (1) describe the design of a PBL-based e-module on the human respiratory system to enhance students' critical thinking skills, and (2) determine the validity of the developed PBL-based e-module based on expert assessment (Dewi et al., 2023; Anggraini & Trimulyono, 2025).

2. Research Method

This study employed the Research and Development (R&D) method using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) (Nurrobi, 2024; Okpatrioka, 2023). Due to time constraints, the research was limited to the Development stage, focusing on product design and validity testing (Dewi et al., 2023).

The validation subjects comprised three experts: two biology education lecturers from Universitas PGRI Ronggolawe Tuban (Dika Agustia Indrati, M.Pd. and Sri Cacik, M.Pd.) and one science teacher from UPT SMPN 4 Tuban (Sofiyani, S.Pd.) (Arikunto, 2013). The e-module was designed using the Canva application with components including cover, usage instructions, learning outcomes, concept maps, materials, PBL-based activities, critical thinking exercises, evaluations, and references (Puspita et al., 2021; Rambe & Ristiono, 2022). The design incorporated PBL syntax across five phases (orienting students to problems, organizing students for learning, guiding investigations, developing artifacts, and analyzing/evaluating solutions) and critical thinking indicators adapted from Facione (1990) (Handayani & Mudlofir, 2024; Sulistianah et al., 2022).

The developed e-module underwent validation by three experts using a Likert-scale questionnaire (1-5) (Mawardi, 2019). The instrument assessed three aspects: material feasibility (11 indicators), language feasibility (5 indicators), and media feasibility (10 indicators) (Arikunto, 2013; Laili et al., 2019). Quantitative data from validation sheets were analyzed using the formula:

Validity Percentage = (Total obtained score / Maximum possible score) × 100% (Arikunto, 2013)

Results were interpreted using Arikunto's (2013) criteria :

- 81%: Very valid
- 61%-80%: Valid
- 41%-60%: Moderately valid
- 21%-40%: Less valid
- <20%: Invalid

Qualitative data (suggestions and comments) were analyzed descriptively for product revision (Sofwatillah et al., 2024).

3. Results and Discussion

3.1. E-Module Design

The developed e-module was designed using Canva and published via an online platform accessible through smartphones or laptops (Puspita et al., 2021). This aligns with findings that mobile learning positively influences critical thinking skills (Santosa, 2024; Suryani, 2025). Key design features include an attractive cover with relevant respiratory system illustrations, clear navigation guidance for independent use, learning outcomes aligned with Merdeka Curriculum Phase D (Grade 8), a visual concept map of respiratory system sub-topics, systematic presentation of materials with images and embedded videos, PBL activities with problem scenarios across five phases, critical thinking tasks targeting all six indicators, Google Form-based evaluation, and properly cited references (Rohmah, 2024; Utari et al., 2023).

The e-module integrates PBL syntax with respiratory system content (Handayani & Mudlofir, 2024). Phase 1 (Problem Orientation) presents authentic scenarios such as "Why do people who live in high-altitude areas have larger lung capacities?" (Mallu et al., 2023). Phase 2 (Student Organization) guides collaborative investigation (Simamora, 2021). Phase 3 (Investigation) directs students to gather information from provided resources (Pratiwi & Mawardi, 2022). Phase 4 (Artifact Development) requires students to present solutions (Sulistianah et al., 2022). Phase 5 (Analysis/Evaluation) facilitates reflection on problem-solving processes (Damayanti, 2023; Khakim et al., 2022).

3.2. Validaty Result

Validation results from three experts are summarized in Table 1 below (Arikunto, 2013).

Table 1. Recapitulation of E-Module Validity Assessment

Aspect	Validator 1	Validator 2	Validator 3	Average	Criteria
Material Feasibility	74.5%	92.72%	98.18%	88.47%	Valid
Language Feasibility	84%	96%	88%	89.33%	Valid
Media Feasibility	78%	90%	94%	87.33%	Valid
Overall Average	78.83%	92.91%	93.39%	88.37%	Valid

The overall average validity of 88.37% indicates that the developed PBL-based e-module meets the criteria for valid learning resources (Arikunto, 2013; Laili et al., 2019). This finding aligns with previous research reporting e-module validity scores ranging from 86% to 95% (Dewi et al., 2023; Sartika et al., 2024; Anggraini & Trimulyono, 2025).

4. Discussion and Conclusion

4.1. Discussion

Material Feasibility: The material feasibility aspect achieved 88.47% (valid). High scores were obtained for alignment between content and learning outcomes, systematic presentation, and appropriateness for students' cognitive development levels (Sidik, 2020; Neviyarni, 2020). The inclusion of critical thinking indicators within the material is particularly significant, as research has shown that PBL-based e-modules effectively train critical thinking when content is aligned with analytical and evaluative tasks (Rizqiyah & Hariani, 2025; Amanda et al., 2024). Validator 1 provided a lower score (74.5%) with suggestions to improve learning outcome formulations, separate concept map phrases, and add evaluation components (Magdalena, 2020). After revision, the learning outcomes were refined to better specify measurable objectives, and the concept map was reorganized for clarity (Dewi Anggelia et al., 2022).

Language Feasibility: Language feasibility achieved 89.33% (valid). Validators assessed the e-module's use of standard Indonesian following Enhanced Spelling System (EYD) rules, communicative sentence structures, and absence of ambiguous meanings (Februari et al., 2024; Sinaga et al., 2024). These findings support research emphasizing that clear, communicative language enhances e-module effectiveness (Zaifullah et al., 2021; Haptanti et al., 2024). Validator 1 identified typographical errors and suggested refining imperative sentences to be more polite and engaging (Ridwan, 2020). After revision, all typographical errors were corrected, and instructional language was adjusted to use more inviting phrasing (Shidqon Famulaqih & Aceng Lukman, 2024).

Media Feasibility: Media feasibility achieved 87.33% (valid). The e-module received positive assessments for cover design, navigation system, font selection, color composition, illustration integration, and supplementary video content (Ahdiyenti et al.,

2022; Mikamahuly et al., 2023). These components align with established criteria for e-module feasibility: clear navigation, interactive design, and multimedia integration (Ibrohim, 2019; Utomo, 2023). Validator 1 noted that the cover lacked visual appeal, images and videos needed supplementation, and figure citations were missing (Muzijah et al., 2020). Revisions included redesigning the cover, adding three instructional videos showing breathing mechanisms and gas exchange processes, and including proper source citations for all images (Purnawanto, 2023; Yahya, 2021).

Comparison with Previous Research: The validity score of 88.37% compares favorably with previous studies. Research on PBL-based e-modules for environmental change material reported validity in the valid category (Dewi et al., 2023). Similarly, e-modules integrating 4C skills for physics material achieved validity scores of 92.71% for media and 91.78% for material (Rohmah, 2024). Literature reviews of e-module development in SINTA-indexed journals confirm that the majority of developed e-modules fall within the valid to very valid categories (Almaas et al., 2025; Sartika et al., 2024). Research trends also show that PBL is more widely applied in physics and chemistry compared to biology, indicating an opportunity for further development of PBL-based resources in biology education (Roza et al., 2023; Anggraini & Trimulyono, 2025).

4.2. Conclusion

Based on the research and development conducted, two main conclusions can be drawn (Arikunto, 2013; Dewi et al., 2023). First, the e-module on the human respiratory system was developed using the ADDIE model, limited to the Development stage. The e-module was designed using the Canva application and published online, incorporating five PBL syntax phases (Handayani & Mudlofir, 2024) and six critical thinking indicators (Facione, 1990). Second, the developed e-module achieved an overall validity percentage of 88.37%, categorized as "valid." Specifically, material feasibility scored 88.47% (valid), language feasibility scored 89.33% (valid), and media feasibility scored 87.33% (valid) (Arikunto, 2013; Laili et al., 2019). These results indicate that the PBL-based e-module on the human respiratory system meets the validity criteria and is suitable for further testing (Nurrobi, 2024; Sartika et al., 2024).

Based on these findings, the following recommendations are proposed (Rohmah, 2024; Anggraini & Trimulyono, 2025). The developed e-module should proceed to implementation and evaluation stages to assess its practicality and effectiveness in improving students' critical thinking skills (Santosa, 2024; Dewi et al., 2023). Teachers may utilize this validated e-module as an alternative learning resource for human respiratory system material (Rizqiyah & Hariani, 2025; Rahmawati & Ramadhan, 2025). Subsequent e-module development should increase the quantity of evaluation questions specifically designed to measure each critical thinking indicator and consider incorporating Augmented Reality technology to further enhance visualization (Muhammad Bakaruddin & Abdullah, 2025; Utari et al., 2023).

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