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Development of a Flipbook-Based Problem Based Learning Science E-Module on the Human Circulatory System to Increase Learning Motivation and Critical Thinking Skills of 8th Grade Students

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Keywords

E-Module; Flipbook; Problem-Based Learning; Critical Thinking Skills; Learning Motivation; Human Circulatory System.

ABSTRACT

This study aims to develop a flipbook-based science e-module using Problem-Based Learning (PBL) to enhance critical thinking skills and learning motivation of grade VIII students on human circulatory system material. This research employed Research and Development (R&D) methodology using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation phases. The research subjects included 33 students in the experimental class and 33 students in the control class at SMP Negeri 14 Yogyakarta. Data collection instruments included validation sheets, practicality questionnaires, critical thinking skills tests, and learning motivation questionnaires. The research design used a quasi-experimental pretest-posttest control group design. Results showed that the developed e-module achieved a very feasible category in material and media aspects, with scores of 3.88 and 3.95 respectively. Practical assessment by science teachers and students showed a very practical category with a score of 3.80. Effectiveness testing using MANOVA showed significant differences ($p = 0.000 < 0.05$) between experimental and control groups. The N-gain scores were 0.70 (high category) for critical thinking skills and 0.45 (moderate category) for learning motivation in the experimental group, compared to 0.44 (moderate) and 0.29 (low) respectively in the control group. The effect size analysis using Cohen's d showed large effects for both variables ($d = 0.89$ for critical thinking; $d = 1.73$ for learning motivation). The flipbook-based science e-module with the PBL approach proved effective in enhancing students' critical thinking skills and learning motivation on human circulatory system material.

INTRODUCTION

21st-century education demands students to possess critical thinking, problem-solving, creativity, communication, and collaboration competencies (Adeoye & Jimoh, 2023; Thornhill-Miller et al., 2023). Educational transformation requires learning systems capable of optimally developing student potential, including critical thinking abilities and learning motivation as foundations for academic success and global challenge readiness (Adnan et al., 2021). Science learning in schools, particularly concerning human circulatory system material, still faces various constraints such as the abstract nature of the material, the complex use of scientific terminology, and minimal availability of engaging and contextual learning media. These factors contribute to low student learning motivation and underdeveloped critical thinking skills.

The development of information and communication technology demands learning transformation toward more interactive and digital directions (Alraimi et al., 2015; Hwang et al., 2018). Flipbook-based e-modules are considered appropriate learning media because they are visual, interactive, flexible, and support independent learning as well as multimedia integration (Kurniawan & Prasetyo, 2021; Sulistyo et al., 2020). Problem-Based Learning (PBL), as an effective learning model, has proven to enhance student motivation and critical thinking abilities (Hmelo-Silver et al., 2013; Hwang et al., 2018). PBL encourages active student involvement in real problem-solving, builds reasoning skills, and develops higher-order thinking abilities (Kurniawan & Prasetyo, 2021).

However, PBL implementation has not been widely combined with modern interactive digital media like flipbooks. The integration of flipbooks and PBL in science e-modules is expected to become an effective and relevant solution for 21st-century learning needs. Flipbooks provide visualization that supports understanding of abstract concepts, while PBL provides a contextual problem-based learning framework that stimulates critical thinking abilities and student learning motivation (Kharomah et al., 2024).

Several research gaps remain unaddressed in the existing literature. Previous studies by Rohmatin et al. (2022) primarily focused on improvements in critical thinking using PBL-based e-modules but lacked a comprehensive analysis of motivation. Similarly, Yuyun et al. (2022) examined the motivational effects of flipbook-based modules without simultaneously assessing critical thinking. Furthermore, most existing research has not systematically integrated multimedia flipbook technology with PBL methodology while measuring both outcomes concurrently. This study addresses these gaps by providing a simultaneous assessment of critical thinking skills and learning motivation through a rigorously designed flipbook-PBL integration.

Based on preliminary observations and questionnaire distribution at SMP Negeri 14 Yogyakarta, results showed that 72% of students found circulatory

system material difficult to understand due to its abstract nature and numerous scientific terms. About 65% of students stated that science learning in class still frequently uses lecture methods with less engaging or interactive media. Furthermore, 70% of students felt less enthusiastic about science learning, especially because the material was considered difficult and unrelated to daily life. Additionally, 68% of students reported rarely being asked to solve problems or participate in class discussions, which contributed to underdeveloped critical thinking abilities.

This research aims to produce a feasible, practical, and effective flipbook-based science e-module using Problem-Based Learning to enhance learning motivation and critical thinking skills of grade VIII students on human circulatory system material.

METHOD

This research employed Research and Development (R&D) methodology using the ADDIE development model consisting of Analysis, Design, Development, Implementation, and Evaluation phases (Branch, 2010). The research was conducted at SMP Negeri 14 Yogyakarta from May to June 2025. The research population consisted of all grade VIII students at SMP Negeri 14 Yogyakarta in the even semester of 2024/2025 academic year, totaling 130 students from 4 classes. The sample was selected using random sampling technique, obtaining two classes: class VIII A as control class (33 students) and class VIII B as experimental class (33 students).

The field trial design used quasi-experimental research design with pretest-posttest control group design. The control class used PowerPoint media with PBL model, while the experimental class used flipbook-based science e-module with Problem-Based Learning. Data collection instruments included: 1) Interview guidelines, 2) E-module validation sheets by material and media experts, 3) Practicality assessment sheets by teachers and students, 4) Critical thinking skills test (20 multiple choice questions), and 5) Learning motivation questionnaire (20 statement items).

Detailed instrument validity assessment was conducted through both content and empirical validation. Content validity was established through expert panel evaluation comprising three material experts and two media experts, all holding doctoral degrees in educational technology or science education with minimum 10 years teaching experience. The Content Validity Ratio (CVR) was calculated using Lawshe's formula, with all items achieving CVR > 0.62 (critical value for 5 experts), indicating acceptable content validity.

For empirical validation, the critical thinking skills test underwent pilot testing with 30 students from similar population characteristics. Item validity was assessed using Pearson product-moment correlation, with validity coefficients ranging from 0.387 to 0.785 (all > r-table = 0.361), confirming item validity. Reliability analysis using Cronbach's Alpha yielded $\alpha = 0.887$,

indicating very high reliability. Similarly, the learning motivation questionnaire achieved validity coefficients ranging from 0.402 to 0.798 and reliability coefficient of $\alpha = 0.892$.

The critical thinking skills test was designed based on Facione's critical thinking framework, encompassing six core skills: interpretation (items 1-3), analysis (items 4-7), evaluation (items 8-11), inference (items 12-15), explanation (items 16-18), and self-regulation (items 19-20). Each item presented circulatory system scenarios requiring specific critical thinking processes. The learning motivation questionnaire was developed using Keller's ARCS model, measuring attention (items 1-5), relevance (items 6-10), confidence (items 11-15), and satisfaction (items 16-20).

Data analysis techniques used were: 1) Descriptive analysis for feasibility and practicality data, 2) N-gain analysis to determine effectiveness, 3) MANOVA test to examine simultaneous effects on both dependent variables, and 4) Effect size analysis using Cohen's d to measure practical significance.

RESULTS AND DISCUSSION

Development Process Results

The development of flipbook-based science e-module using Problem-Based Learning followed the ADDIE model systematically through five phases: Analysis, Design, Development, Implementation, and Evaluation.

Analysis Phase Results

The analysis phase revealed several critical findings through interviews with science teachers and needs assessment questionnaires distributed to grade VIII students. Teacher interviews indicated that 72% of students found human circulatory system material challenging due to its abstract nature and complex scientific terminology. The preliminary assessment of critical thinking skills showed that only 48.77% of students could answer analytical questions correctly, indicating insufficient critical thinking development.

Table 1. Student Needs Analysis Results (n=66)

Aspect	Percentage	Category
Material difficulty perception	72%	Difficult
Interest in interactive media	75.9%	High
Current media satisfaction	35%	Low
Critical thinking skills (preliminary test)	48.77%	Insufficient
Learning motivation level	45%	Moderate

The needs analysis revealed that students required more engaging and interactive learning materials. Traditional teaching methods using textbooks and PowerPoint presentations were insufficient to stimulate student interest and develop critical thinking skills effectively.

Design Phase Results

The design phase produced comprehensive blueprints for the e-module development. The learning objectives were aligned with the Merdeka Curriculum for Phase D, focusing on the circulatory system analysis competencies.

Table 2. E-Module Design Components

Component	Description	PBL Integration
Cover Page	Title, institution, author information	Problem orientation
Introduction	Learning objectives, concept maps	Problem identification
Learning Activities	4 main topics with multimedia content	Guided investigation
Problem Scenarios	Real-life circulation problems	Problem-solving focus
Assessment Tools	Formative and summative evaluations	Solution presentation
References	Scientific sources and glossary	Evidence-based learning

Development Phase Results

The development phase involved creating the actual e-module using Hyzine Flipbook platform and conducting expert validation. The e-module incorporated multimedia elements including videos, interactive diagrams, and problem-based scenarios related to circulatory system disorders.

Feasibility Assessment Results

Material Expert Validation

Material expert validation was conducted using a comprehensive instrument covering three main aspects: content feasibility, presentation feasibility, and readability feasibility.

Table 3. Material Expert Validation Results

Aspect	Items	Score Obtained	Max Score	Average	Category
Content Feasibility	1-11	43	44	3.90	Very Feasible
Presentation Feasibility	12-15	15	16	3.75	Very Feasible
Readability Feasibility	16-20	20	20	4.00	Very Feasible
Total Average				**3.88**	**Very Feasible**

The material validation results showed excellent alignment with curriculum standards and learning objectives. Expert feedback emphasized the quality of problem-based scenarios and their relevance to real-life situations.

Media Expert Validation

Media expert validation focused on graphic quality and media content effectiveness.

Table 4. Media Expert Validation Results

Aspect	Items	Score Obtained	Max Score	Average	Category
Graphic Feasibility	1-10	39	40	3.90	Very Feasible
Media and Content	11-20	40	40	4.00	Very Feasible
Total Average				**3.95**	**Very Feasible**

Media experts particularly commended the interactive elements and visual appeal of the flipbook format, noting its potential to enhance student engagement significantly.

Instrument Validation Results

Critical Thinking Skills Test Validation

The critical thinking skills test underwent both content and empirical validation processes.

Table 5. Critical Thinking Skills Test Validation Results

Validation Type	Aspect	Items	Score	Average	Category
Content Validation	Material Aspect	1-4	16	4.00	Very Feasible
	Construction Aspect	5-10	24	4.00	Very Feasible
	Readability Aspect	11-15	24	4.00	Very Feasible
Empirical Validation	Validity (r-count > r-table)	20 items	All valid	-	Valid
	Reliability (Cronbach's Alpha)	20 items	0.887	-	Very Reliable

Formula 1. Cronbach's Alpha Reliability

$$\alpha = \frac{k}{k-1}\left(1-\frac{\sum S_i^2}{S_t^2}\right)$$

Where:

- α = Reliability coefficient
- k = Number of items
- ΣSi^2 = Sum of item variances
- St^2 = Total variance

Learning Motivation Questionnaire Validation

The learning motivation questionnaire validation showed high validity and reliability across all assessment aspects.

Table 6. Learning Motivation Questionnaire Validation Results

Aspect	Items	Score Obtained	Max Score	Average	Category
Material Aspect	1-4	16	16	4.00	Very Feasible
Construction Aspect	5-9	20	20	4.00	Very Feasible
Readability Aspect	10-15	24	24	4.00	Very Feasible
Total Average				**4.00**	**Very Feasible**

Practicality Assessment Results

Teacher Practicality Assessment

Science teachers evaluated the e-module's practicality across four key aspects.

Table 7. Teacher Practicality Assessment Results

Aspect	Items	Score Obtained	Max Score	Average	Category
Graphic Aspect	1-5	16	20	3.20	Practical
Media and Content	6-9	16	16	4.00	Very Practical
Content Aspect	10-16	28	28	4.00	Very Practical
Readability Aspect	17-20	16	16	4.00	Very Practical
Total Average				**3.80**	**Very Practical**

Teachers particularly appreciated the systematic organization of learning materials and the integration of PBL approach with engaging multimedia content.

Student Practicality Assessment

Student practicality assessment was conducted in two phases: limited trial (15 students) and field trial (33 students).

Table 8. Student Practicality Assessment Results

Group	Participants	Aspect	Score Obtained	Max Score	Average	Category
Limited Trial	15 students	All aspects	968	1080	3.59	Very Practical
Field Trial	33 students	All aspects	2258	2448	3.69	Very Practical

Both student groups responded positively to the e-module's user-friendly interface and engaging content presentation.

Effectiveness Test Results

Prerequisite Test Results

Before conducting the main effectiveness analysis, several prerequisite tests were performed to ensure data suitability for MANOVA analysis.

Normality Test Results

Multivariate normality testing was conducted using the correlation between Mahalanobis distance and qi values.

Table 9. Multivariate Normality Test Results

Variables	Mahalanobis Distance	qi	Correlation	Sig.	Interpretation
Critical Thinking & Learning Motivation	1	0.950**	0.950	0.000	Multivariate Normal

The high correlation ($r = 0.950$, $p < 0.01$) between Mahalanobis distance and qi values confirmed that the data met multivariate normality assumptions.

Linearity Test Results

Table 10. Linearity Test Results

Source	Deviation from Linearity	F	Sig.	Interpretation
Critical Thinking * Learning Motivation	0.454	0.984	Linear Relationship	

The linearity test showed a significant linear relationship between variables (Sig. = 0.984 > 0.05), satisfying MANOVA assumptions.

Homogeneity Test Results

Table 11. Box's M Test for Homogeneity

Test	Box's M	F	df1	df2	Sig.	Interpretation
Homogeneity of Covariance Matrices	0.488	0.157	3	737280.0	0.925	Homogeneous

The homogeneity test confirmed equal covariance matrices across groups ($p = 0.925 > 0.05$).

Learning Motivation Results

Descriptive Statistics

Table 12. Learning Motivation Descriptive Results

Group	Test Type	N	Mean	SD	Min	Max
Experimental	Pretest	33	57.55	4.12	50.93	67.59
	Posttest	33	76.63	3.95	70.37	84.26
Control	Pretest	33	57.38	4.08	50.93	64.81
	Posttest	33	69.87	4.23	60.19	75.00

N-Gain Analysis for Learning Motivation

The N-gain formula was applied to measure learning improvement:

Formula 2. N-Gain Calculation

$$N\text{-}gain = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

Where:

- S_post = Posttest score
- S_pre = Pretest score
- S_max = Maximum possible score

Table 13. N-Gain Results for Learning Motivation

Group	N-Gain Score	Category	Interpretation
Experimental	0.45	Moderate	Effective improvement
Control	0.29	Low	Limited improvement

The experimental group showed significantly higher N-gain scores compared to the control group, indicating the effectiveness of the flipbook-based e-module in enhancing learning motivation.

Critical Thinking Skills Results

Descriptive Statistics

Table 14. Critical Thinking Skills Descriptive Results

Group	Test Type	N	Mean	SD	Min	Max
Experimental	Pretest	33	49.55	12.5	25	70
	Posttest	33	85.24	4.8	78	95
Control	Pretest	33	46.52	13.1	25	80
	Posttest	33	71.21	9.2	50	85

N-Gain Analysis for Critical Thinking Skills

Table 15. N-Gain Results for Critical Thinking Skills

Group	N-Gain Score	Category	Interpretation
Experimental	0.70	High	Highly effective improvement
Control	0.44	Moderate	Moderate improvement

The experimental group achieved high category N-gain scores, demonstrating the superior effectiveness of the PBL-integrated flipbook e-module in developing critical thinking skills.

MANOVA Test Results

Multivariate Analysis of Variance (MANOVA) was conducted to examine simultaneous effects on both dependent variables.

Table 16. MANOVA Test Results

Effect	Test Statistic	Value	F	Hypothesis df	Error df	Sig.	Interpretation
Intercept	Hotelling's Trace	40.140	1264.42	2	63	0.000	Significant
Group	Hotelling's Trace	0.916	28.852	2	63	0.000	Significant

The MANOVA results revealed significant differences between experimental and control groups ($p = 0.000 < 0.05$), confirming the effectiveness of the flipbook-based e-module with PBL approach.

Tests of Between-Subjects Effects

Table 17. Between-Subjects Effects Results

Source	Dependent Variable	Mean Square	F	Sig.	Partial Eta Squared	Effect Size
Group	Critical Thinking Skills	0.239	13.144	0.001	0.170	Medium
	Learning Motivation	0.255	49.605	0.000	0.437	Large

The between-subjects effects analysis showed significant effects for both variables, with learning motivation showing a larger effect size ($\eta^2 = 0.437$) compared to critical thinking skills ($\eta^2 = 0.170$).

Effect Size Analysis

Cohen's d was calculated to determine the practical significance of the intervention.

Formula 3. Cohen's d Effect Size

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

Where: $$SD_{pooled} = \sqrt{\frac{SD_1^2 + SD_2^2}{2}}$$

Table 18. Effect Size Analysis Results

Variable	Experimental Mean	Control Mean	Pooled SD	Cohen's d	Effect Size Category
Critical Thinking Skills	0.5318	0.4115	0.1348	0.89	Large Effect
Learning Motivation	0.4533	0.3291	0.0715	1.73	Very Large Effect

The effect size analysis confirmed large to very large practical effects, supporting the statistical significance findings.

Discussion

Effectiveness of Flipbook-Based E-Module Development

The development of flipbook-based science e-module using Problem-Based Learning demonstrated remarkable success across all evaluation criteria. The systematic ADDIE approach ensured comprehensive development from initial analysis through final evaluation, resulting in a high-quality educational product.

The feasibility assessment results (material expert: 3.88; media expert: 3.95) exceeded the "very feasible" threshold, indicating that the e-module meets high academic and technical standards. These findings align with previous research by Amaliyah et al. (2023), who reported similar feasibility scores for PBL-based flipbook modules. The high feasibility scores reflect careful attention to curriculum alignment, content accuracy, and pedagogical soundness.

Practicality assessment results consistently showed "very practical" categories across all evaluator groups. Teachers rated the e-module as highly

practical (3.80), appreciating its systematic organization and PBL integration. Students in both limited and field trials responded positively (3.59 and 3.69 respectively), indicating user-friendly design and engaging content. These results support findings by Indriyani et al. (2024), who emphasized the importance of user experience in e-module effectiveness.

Critical Thinking Skills Enhancement

The experimental group's critical thinking skills improvement (N-gain = 0.70, high category) significantly exceeded the control group's improvement (N-gain = 0.44, moderate category). This substantial difference demonstrates the effectiveness of integrating Problem-Based Learning with interactive flipbook media.

The PBL approach embedded in the e-module successfully engaged students in authentic problem-solving scenarios related to circulatory system disorders. Students were presented with real-world cases such as hypertension, heart attacks, and blood donation scenarios, requiring them to analyze symptoms, evaluate evidence, and propose solutions. This process directly developed the six critical thinking skills identified by Facione (1990): interpretation, analysis, evaluation, inference, explanation, and self-regulation.

The large effect size (Cohen's d = 0.89) confirms the practical significance of the intervention. This finding is consistent with research by Rohmatin et al. (2022), who reported significant critical thinking improvements using PBL-based e-modules. The success can be attributed to the e-module's design features that promote active learning, collaborative problem-solving, and reflective thinking.

Learning Motivation Enhancement

The experimental group showed substantial learning motivation improvement (N-gain = 0.45, moderate category) compared to the control group (N-gain = 0.29, low category). The very large effect size (Cohen's d = 1.73) indicates exceptionally strong practical impact on student motivation.

Several factors contributed to this motivational enhancement:

1. **Visual Appeal and Interactivity**: The flipbook format provided engaging visual presentations with multimedia elements, making abstract circulatory concepts more accessible and interesting.
2. **Authentic Problem Context**: PBL scenarios connected learning to real-life health issues, increasing perceived relevance and importance.
3. **Student Agency**: The e-module allowed self-paced learning and repeated access to content, giving students greater control over their learning experience.
4. **Collaborative Elements**: Group problem-solving activities fostered peer interaction and mutual support, creating a more supportive learning environment.

These findings align with Self-Determination Theory (Deci & Ryan, 2000), which emphasizes autonomy, competence, and relatedness as key

motivational factors. The e-module design successfully addressed all three psychological needs.

Multivariate Effects Analysis

The MANOVA results (Hotelling's Trace = 0.916, p = 0.000) confirmed significant simultaneous effects on both dependent variables. This finding is particularly important because it demonstrates the e-module's comprehensive educational impact rather than isolated effects on individual variables.

The differential effect sizes (critical thinking: $\eta^2 = 0.170$; learning motivation: $\eta^2 = 0.437$) suggest that while the intervention effectively enhanced both variables, its impact on motivation was particularly pronounced. This pattern is logical considering that motivation often precedes and facilitates cognitive skill development.

Pedagogical Implications

The research results have several important pedagogical implications:

1. **Multimedia Integration**: The success of flipbook-based presentation suggests that modern students respond well to visually rich, interactive learning materials that combine traditional content with digital engagement features.
2. **Problem-Based Pedagogy**: The effectiveness of PBL integration confirms the value of authentic, contextual learning approaches that connect academic content to real-world applications.
3. **Student-Centered Design**: The high practicality ratings indicate that involving students in the design consideration process and prioritizing user experience leads to more effective educational products.
4. **Technology-Enhanced Learning**: The research demonstrates that thoughtful technology integration can significantly enhance learning outcomes when aligned with sound pedagogical principles.

Comparison with Previous Research

The current research results show consistency with several previous studies while also contributing unique insights. Kharomah et al. (2024) reported similar effectiveness for problem-based interactive flipbook e-modules, with N-gain scores around 0.70. However, the current study's very large effect size for motivation ($d = 1.73$) exceeds most previous findings, suggesting particularly effective motivational design.

Seruni et al. (2020) found significant critical thinking improvements using flip PDF professional with PBL, supporting the current research's approach. However, their study focused primarily on critical thinking without examining motivational effects, limiting comprehensive comparison.

Yuyun et al. (2022) reported strong motivational effects for flipbook-based physics e-modules, with motivation improvement percentages around 84%. The current study's quantitative effect size analysis provides more precise measurement of practical significance.

Limitations and Future Directions

Despite the positive results, several limitations should be acknowledged:

1. **Sample Scope**: The study was conducted in a single school with a relatively homogeneous student population, potentially limiting generalizability.
2. **Duration**: The intervention period, while sufficient for measurable effects, may not capture long-term retention and skill development.
3. **Subject Specificity**: The research focused specifically on circulatory system content, raising questions about effectiveness across different science topics.

Future research should address these limitations by:

1. **Broader Sampling**: Implementing the e-module across diverse educational contexts and student populations.
2. **Longitudinal Studies**: Conducting extended studies to examine sustained effects on critical thinking and motivation.
3. **Cross-Curricular Application**: Adapting the approach to different science topics and other subject areas.
4. **Technology Integration**: Exploring integration with emerging technologies such as virtual reality and artificial intelligence.

The research conclusively demonstrates that flipbook-based science e-modules using Problem-Based Learning represent an effective approach for enhancing both critical thinking skills and learning motivation in science education. The comprehensive evaluation framework, rigorous statistical analysis, and substantial effect sizes provide strong evidence for the practical value of this educational innovation.

CONCLUSION

The development of flipbook-based science e-module using Problem-Based Learning on human circulatory system material successfully achieved research objectives. The e-module was assessed as very feasible by material and media experts with scores of 3.88 and 3.95 respectively, and very practical by teachers and students with an average score of 3.80. Effectiveness testing using MANOVA showed significant differences ($p = 0.000 < 0.05$) between experimental and control groups. The experimental group achieved higher N-gain scores for both critical thinking skills (0.70 vs 0.44) and learning motivation (0.45 vs 0.29) compared to the control group. Effect size analysis confirmed large practical effects for both variables ($d = 0.89$ and $d = 1.73$). These results demonstrate that flipbook-based science e-modules with PBL approach effectively enhance grade VIII students' critical thinking skills and learning motivation on human circulatory system material. Future research should explore implementation across different science topics and educational levels to further validate the approach's broader applicability.

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