



Enhancing knowledge and critical thinking about health through biology instruction based on the health belief model among secondary school students

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Article Information	ABSTRACT
<p>Article History: Submitted: 2025-05-08 Revised: 2025-12-21 Accepted: 2025-12-22 Published: 2025-12-31</p> <p>Keywords: Biology; critical thinking skills; health belief model; learning outcome; PBL</p>	<p>Health and well-being are paramount objectives within the Sustainable Development Goals (SDGs). Numerous health challenges endure due to insufficient early health teaching in educational institutions. Nonetheless, scant research has amalgamated school-based education with essential health principles. This study aimed to examine the effect of problem-based learning (PBL) based on the health belief model (HBM), also referred to as HB-PBL, on students' learning outcomes and critical thinking skills. The type of research is a quasi-experimental design featuring a pre-test and post-test with a non-equivalent control group. The sample was 70 12th-grade science students at SMAN 3 Malang, Indonesia. Students participated in cooperative problem-solving centered on human heredity and inherited disorders. Instrument research is a type of exam that consists of multiple-choice questions and an essay. The data obtained were analyzed using analysis of covariance (ANCOVA) at a 95% confidence level. ANCOVA results showed that the instructional method had a significant effect on both learning outcomes and critical thinking skills, with a significance value below 0.05 ($p < 0.05$). This study demonstrated that HB-PBL significantly improves students' learning outcomes and critical thinking skills by fostering greater engagement with health-related issues. Subsequent research ought to examine the impact of health attitudes on students' learning behaviors.</p>
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INTRODUCTION

The Sustainable Development Goals (SDGs) designate well health and well-being as a paramount objective for enhancing global welfare. Numerous SDGs targets emphasize the necessity of guaranteeing universal access to high-quality healthcare services and decreasing mortality rates from both communicable and non-communicable diseases (Kruk et al., 2018; Ndumwa et al., 2023). All instructional elements should be oriented toward the effective dissemination of health education. Schools serve as an ideal platform for health education, reaching all children systematically to promote health literacy,

behaviors, and wellbeing through integrated curricula and environments (Pulimeno et al., 2020). Promoting sustainable health development among students who embody the young and future of society will effectively involve increasing health-awareness (Jeihooni et al., 2018).

However, numerous community health issues stem from insufficient health promotion inside educational institutions. The Covid-19 pandemic exposed systemic vulnerabilities within educational frameworks, specifically a lack of readiness in equipping students to navigate intricate health risks and the surge of misinformation. During the crisis, educational responses largely prioritized maintaining lesson delivery over fostering students' ability to critically evaluate health-related data (Tan et al., 2025). Moreover, health education in schools is often addressed through fragmented campaigns rather than integrated into learning (Asghar & Macintosh, 2025). In this contest, the biology subject presents a strategic opportunity to enhance students' awareness of healthy lifestyles and illness prevention in the school setting (Pulimeno et al., 2020).

Critical thinking skills are vital for tackling complicated health concerns that necessitate thorough examination and inventive solutions. This encompasses the analysis of information, the application of decision-making strategies, the openness to new perspectives, the use of logical reasoning, the drawing of inferences, the evaluation of evidence, the testing of conclusions, the formulation of accurate judgments, and the examination of assumptions (Greenstein, 2012). Critical thinking competencies align with the advanced tiers of Bloom's taxonomy, specifically analysis, assessment, and innovation (Van der Zanden et al., 2020). Critical thinking plays a key role in making decisions, this is including approaches to specific questions or problems, approaches to life in general, and approaches to cognitive skills (Sharples et al., 2017).

It is essential to acknowledge that before critical thinking can be developed as a higher-order cognitive skill, students must first establish foundational cognitive capacities. Knowledge constitutes a fundamental skill, encompassing the capacity to retrieve certain information, including the sequential steps of a specified procedure (Adams, 2015). According to the cognitive process dimensions, learning progresses hierarchically from lower to higher-order thinking skills, namely remember, understand, apply, analyse, evaluate, and create (Asmussen et al., 2023). Critical thinking is predominantly situated within these higher-order cognitive processes. Therefore, instructional approaches that aim to foster critical thinking must be deliberately structured to support this cognitive progression.

Educational institutions frequently implement the problem-based learning (PBL) framework to improve students' critical thinking abilities. The PBL paradigm enhances students' clinical reasoning, decision-making, and case conceptualization skills as they navigate many checkpoints and scenarios rooted in authentic healthcare circumstances (Chung, 2019). Problem-based learning with argumentation (PBLA) has demonstrated efficacy in enhancing critical thinking abilities in junior high school pupils (Akhdinirwanto et al., 2020). Moreover, research indicates that problem-based learning (PBL) augmented by metacognitive prompts facilitates the enhancement of students' knowledge, reasoning, and critical thinking skills (Marthaliakirana et al., 2022). Previous studies also found that PBL integrated with health literacy intervention improves health-promoting behaviors (Mohebi et al., 2018). Another study using PBL was used for promoting biology-health literacy (Suwono et al., 2023). Nonetheless, there is a paucity of research that integrates PBL with the fundamental principles of health.

Several studies documented the beneficial outcomes of an educational program developed in accordance with the health belief model (HBM). A study assessing health beliefs reveals HBM as an efficacious health promotion technique (Agustin et al., 2021). Incorporating the HBM into health education allows students to acquire knowledge and foster a sense of personal accountability for their health

(Keshavarz et al., 2022). The HBM is a psychological framework utilised to elucidate and forecast health-related behaviours, grounded in individuals' beliefs and attitudes concerning a particular health issue. Health belief assessments include factors like perceived vulnerability, perceived severity, perceived advantages, perceived barriers, and self-efficacy (Rosenstock et al., 1988). There is research adding cues to action (Wu et al., 2020). Perceived susceptibility denotes an individual's evaluation of their risk of disease and the acknowledgement of possible adverse consequences. Perceived severity pertains to the extent to which an individual regards an illness, ailment, or bad event as serious, encompassing its potential ramifications. Perceived barriers are obstacles that impede the adoption of prescribed behaviours, whereas perceived advantages are the advantageous results linked to those behaviours. Self-efficacy denotes an individual's conviction in their ability to effectively execute particular tasks (Green et al., 2020; Rosenstock et al., 1988).

Meanwhile, the HBM is not implemented alongside PBL. Understanding its effectiveness would allow educators to adopt the HBM as a pedagogical framework or integrate it with other instructional models. Therefore, it is crucial to examine current evidence and identify the effect of learning with HBM, especially when combined with PBL. The objective of this study was to examine the effect of health belief-based problem-based learning (HB-PBL) on students' cognitive learning outcomes and critical thinking skills. This study addresses a significant gap in integrating the HBM into classroom health learning, where current approaches remain fragmented and rarely leverage the HBM systematically to build knowledge and critical thinking through behavior-belief-based instruction. Moreover, this learning underscores the HBM as a theoretical framework for comprehending health behaviours within a learning context. In this learning, students engage in collaborative PBL approaches to devise health-related solutions for human heredity and inherited disorders.

RESEARCH METHODS

The type of research is a quasi-experimental approach, incorporating a pre-test and post-test non-equivalent control group methodology. This study aimed to evaluate the effect of the independent variable on the dependent variable. The learning method served as the independent variable, whereas cognitive learning outcomes and critical thinking abilities functioned as the dependent variables. The independent variables comprised the PBL and HB-PBL models. The samples consisted of 70 twelfth-grade science students from a SMAN 3 Malang, Indonesia, specialising in science/biology. The control group comprised 14 males and 22 females, whereas the experimental group consisted of 8 males and 26 females. The research design of the study can be seen in Table 1.

Table 1. Research Design of the Study

Group	Class	Number of Students	Gender Distribution	Pre-test	Treatment	Post-test
Experimental Group	XII Science (Biology)	34	8 males, 26 females	O ₁	X	O ₂
Control Group	XII Science (Biology)	36	14 males, 22 females	O ₁	-	O ₂
Total	-	70	22 males, 48 females	-	-	-

Notation: O₁ = Pre-test; O₂ = Post-test; X = Experimental treatment; & - = No treatment

The research was planned for both groups that were tasked with studying the identical biology subject, namely human heredity patterns and inherited disorders. The PBL methodology was executed,

necessitating students to submit assignments focused on problem-solving in biology. Both groups participated in 90-minute sessions over three weeks, employing different PBL methodologies. Prior to and following the modules, both groups undertook a multiple-choice examination and an essay to evaluate their comprehension.

The second study group employed the PBL concept. The conventional PBL model was employed in the initial research group. Students were organised into groups and commenced the learning process by viewing a film on diseases resulting from genetic inheritance. The teacher supplied pupils with worksheets designed in accordance with PBL syntax. The teacher subsequently presented a provocative question pertinent to the issue. Students commenced the problem orientation phase with a case chosen by the teacher, namely the case of Down syndrome. During the student organisation phase for learning, the teacher facilitated the identification of essential questions and verified their precision. Students performed solo and collaborative research, assessing data and correlating it with the principles and facts of human hereditary patterns. Subsequently, students participated in discussions to identify answers, systematically arranging their findings into written responses or diagrams. They created and showcased their work to the class, integrating diverse viewpoints in a manner that was coherent and comprehensible to others. At this juncture, both the teacher and the students assessed and scrutinised the problem-solving process while participating in reflective learning activities.

The second study group employed the HB-PBL model, integrating the PBL methodology with the HBM. The teacher supplied students with worksheets designed in accordance with the HB-PBL framework. Students initiated the problem orientation phase with a stimulus comprising a movie on disorders resulting from genetic inheritance, followed by a provocative question posed by the teacher about the issue. The teacher facilitated students in their groups to choose a problem or disease to tackle, utilising a set of provided worksheets. Students subsequently assessed their family's health history concerning the notion of perceived susceptibility, reflecting on their conviction regarding the probability that their offspring may encounter analogous health problems in the future. Students were directed to select the issue they desired to address, contingent upon their assessment of the disease's impact on their progeny, illustrating the notion of perceived severity. They were additionally prompted to evaluate the prospective severity of the condition on subsequent generations, which corresponded with this notion. Upon selecting their focus, students proceeded to the independent and collaborative research phase, during which they selected media and educational resources for data collection and critical thinking. They devised solutions grounded in their conviction of the advantages of implementing preventive or corrective measures, sometimes referred to as perceived benefits. Students were urged to analyse possible impediments to action, like expense, time constraints, or complexity. Subsequently, students articulated their discoveries as solutions derived from several logical approaches. They were assigned the responsibility of devising tactics to promote the adoption of their recommended solutions. Finally, students were encouraged to reflect on their learning and articulate their confidence in executing preventive measures, along with the notion of self-efficacy. This process acts as a stimulus for action, encouraging students to participate in health-enhancing habits. The HB-PBL framework is shown in [Figure 1](#).

The instruments of this research were validated by three biologists from Malang State University. The syllabus obtained a validity score of 97.5% from the subject matter expert and 99% from the learning design expert. The lesson plan was also rated highly, with a score of 99% from the learning design expert and 98.1% from the subject matter expert. Furthermore, the independent learning activity received a score of 100% from the learning design expert and 94.2% from the subject matter expert. The assessment

instrument was validated by an assessment expert and achieved a score of 99.7%. These findings indicate that instruments and learning devices were appropriate and feasible for use in the study.

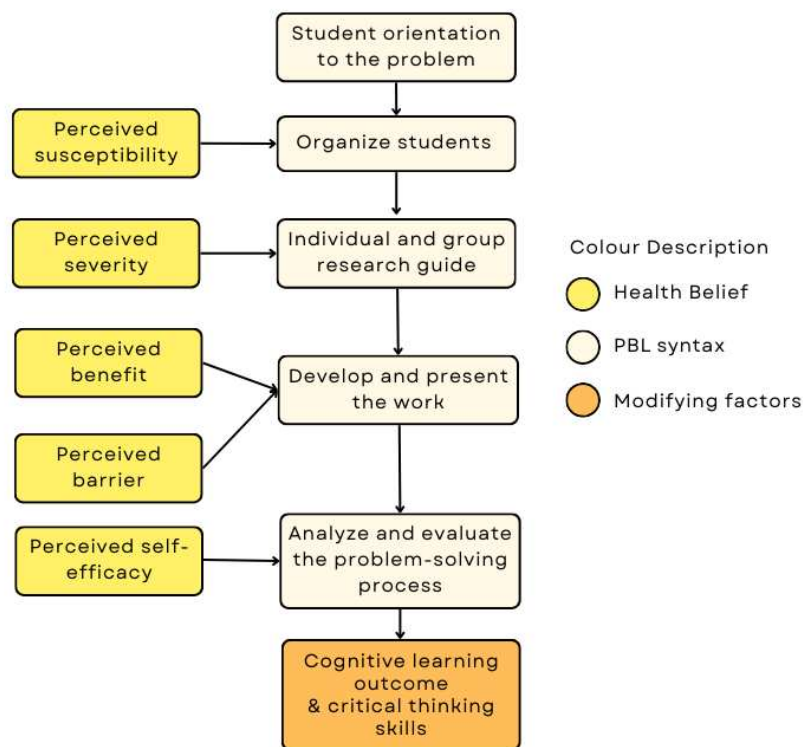


Figure 1. HB-PBL framework

Students comprising exam questions that undertook 45 minutes of tests of 15 multiple-choice questions, designed to assess cognitive learning results. The multiple-choice questions were formulated according to Bloom's Taxonomy levels: C1 (4 questions), C3 (4 questions), C4 (3 questions), C5 (3 questions) by Krathwohl (2002). The critical thinking skills assessment had five essay questions, requiring 30 minutes for completion. The questions aligned with the four essential components of critical thinking as delineated in Greenstein's model: (1) critical thinking, (2) analysing information, (3) using data to develop critical insights, (4) synthesizing multiple viewpoints (Greenstein, 2012). The essay is based on Bloom's taxonomy level as follows: C3 (1 question), C4 (1 question), C5 (1 question), C6 (1 question). The results from this study encompassed cognitive learning outcomes and scores in critical thinking skills. The data analysis technique to evaluate the presence of a significant difference in test score enhancements was the variance and mean samples from the pre- and post-test data of the two methodologies, which were analysed using analysis of covariance (ANCOVA) at a 95% confidence level.

FINDING AND DISCUSSION

The cognitive learning outcomes of PBL and HB-PBL can be seen in Table 2. Prior to executing the ANCOVA test to assess the impact of the learning technique on learning outcomes, preliminary analyses were conducted to verify the fulfillment of fundamental assumptions. The normality test revealed a significance value over 0.05, signifying that the data adhered to a normal distribution. The outcomes of the normality assessment and the homogeneity of variance test for the pre-test and post-test data groups, as presented in Table 3, indicated a significance value over 0.05, signifying that the variance among the groups was normal and homogeneous. The outcomes of the normality and homogeneity tests provide the

basis for advancing to subsequent statistical analysis, specifically ANCOVA. The ANCOVA findings indicated a substantial impact of the HB-PBL model on cognitive learning outcomes, with a significance level of $p < 0.05$ as shown in Table 4.

Table 2. Cognitive Learning Outcomes of PBL and HB-PBL

Stage	Group	Mean	Min	Max	Standard Deviation
Pretest	PBL	65.00	50	78	8.93149
	HB-PBL	69.55	54	84	9.97023
Posttest	PBL	78.55	60	90	7.62119
	HB-PBL	89.97	81	97	4.96341

Table 3. Normality and Homogeneity Test Results

Stage	Group	Normality Test Sig.	Interpretation	Homogeneity Test Sig.	Interpretation
Pretest	PBL	0.138	Normal	0.376	Homogeneous
	HB-PBL	0.200	Normal		
Posttest	PBL	0.014	Normal	0.055	Homogeneous
	HB-PBL	0.200	Normal		

Table 4. Results of the ANCOVA Learning Outcomes Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2789.457a	2	1394.729	40.023	0.000	.544
Intercept	5517.805	1	5517.805	158.337	0.000	.703
X	511.017	1	511.017	14.664	0.000	.180
Y	1680.515	1	1680.515	48.224	0.000	.419
Error	2334.843	67	34.848			
Total	500221.000	70				
Corrected Total	5124.300	69				

Table 5 presents the evaluation of critical thinking skills. ANCOVA was performed to assess the impact of the treatment on critical thinking abilities. Before this, the data were evaluated to confirm their compliance with the assumptions for ANCOVA. The normality and homogeneity test revealed a significance value exceeding 0.05, suggesting that the data were normally and homogeneous distributed, as shown in Table 6. The significance value for the homogeneity test in the pre-test group was 0.376, while in the post-test group, it was 0.055. As both values exceed 0.05, this signifies that the variance among the groups is equal, so affirming the homogeneity of the data. Upon satisfying the assumptions, an ANCOVA test was performed, revealing that the HB-PBL Model significantly enhanced critical thinking skills. The ANCOVA findings, with a significance level of $p < 0.05$, demonstrate a substantial disparity in critical thinking skills after adjusting for the pre-test scores, as illustrated in Table 7.

Table 5. Critical Thinking Skills of PBL and HB-PBL

Stage	Group	Mean	Min	Max	Standard Deviation
Pretest	PBL	35.47	25	56	8.83980
	HB-PBL	36.79	25	56	9.53075
Posttest	PBL	67.61	44	87	10.09746
	HB-PBL	74.32	62	87	7.81886

Table 6. Normality and Homogeneity Test Results

Stage	Group	Normality Test Sig.	Interpretation	Homogeneity Test Sig.	Interpretation
Pretest	PBL	0.063	Normal	0.922	Homogeneous

Stage	Group	Normality Test Sig.	Interpretation	Homogeneity Test Sig.	Interpretation
Posttest	HB-PBL	0.167	Normal	0.073	Homogeneous
	PBL	0.051	Normal		
	HB-PBL	0.078	Normal		

Table 7. ANCOVA critical thinking skills PBL and HB-PBL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1674.009a	2	837.005	11.932	.000	.263
Intercept	13310.328	1	13310.328	189.750	.000	.739
X	667.011	1	667.011	9.509	.003	.124
Y	886.163	1	886.163	12.633	.001	.159
Error	4699.834	67	70.147			
Total	357967.000	70				
Corrected Total	6373.843	69				

The application of HB-PBL has been shown to affect the students' cognitive learning outcome, primarily due to heightened motivation stemming from their curiosity regarding health-related subjects. Both the PBL and HB-PBL groups examined topics like genetic inheritance, but the strategy differentiated itself by choosing questions based on students' judgments based on their perceived susceptibility and severity. This relevance-oriented problem framing strengthens personal engagement with the subject, a crucial factor in fostering intrinsic motivation. As students gain awareness of the potential hazards and benefits linked to diverse health behaviours, their inclination to comprehend and regulate these elements effectively increases (Lesińska-Sawicka et al., 2021). This increased curiosity enhances their involvement with the material and fosters a more proactive learning approach.

Additionally, the notion of self-efficacy is a fundamental element of health belief models that significantly influences scholastic and cognitive performance. Studies indicate that persons possessing high self-efficacy might mitigate the adverse impacts of low educational achievement, especially in activities requiring cognitive flexibility, like set-switching and attention/inhibition (Zahodne et al., 2015). This indicates that HB-PBL not only facilitates subject mastery but may also cultivate vital cognitive skills. This positive effect is relevant to previous studies. Health literacy-tailored education and counseling, structured around the HBM construct, modify health belief dan predict greater patient engagement and self-efficacy in managing diseases (Ağralı & Akyar, 2022).

HB-PBL learning is also significantly affected critical thinking skills. The HBM posits that health education is most efficacious when consumers regard a health concern as significant and personally pertinent (Gustafson et al., 2007). This perspective fosters enhanced involvement and more profound insight. Critical thinking, however, may be obstructed by biases, social influences, and inadequate risk evaluation. Consequently, educators should not only cultivate critical thinking but also evaluate whether students recognise significant advantages from their learning (Aston, 2023). HB-PBL facilitates this as learning strategy by utilising fundamental HBM components, perceived vulnerability and self-efficacy, which are essential for fostering behavioural change in disease prevention and health management (Firmansyah & Salsabil, 2022; Kam & Lee, 2024). Studies indicate that individuals' health perceptions affect their critical thinking in health-related decision-making (Settersten & Lauver, 2004). However, a study demonstrated that critical thinking can be effectively developed without employing HBM. For example, research by Pulimeno et al. (2020) indicated that medical students were able to enhance their critical thinking skills following direct instrution, despite initially low scores in certain subscales. Notably,

scores in analysis, evaluation, and inductive reasoning improved significantly, which may be attributed to the programs' duration and the implementation of explicit critical thinking instruction.

Previous study has found that greater perceived barriers and fewer perceived benefits were associated with lower engagement in preventive behaviors among high-risk Chinese populations (Niu et al., 2022). In contrast, our study could not identify which aspects of the HBM significantly contributed to the higher learning outcomes and critical thinking scores, possibly because the sample consisted of generally healthy students. This aligns with the research involving general population, where the majority were free from chronic conditions, suggesting that perceived benefit could not yet be established as a reliable predictor of health behaviors (Zhang et al., 2022).

The efficacy of HB-PBL is contingent upon the proficient execution of PBL. This method positions the teacher as a facilitator, directing students to investigate topics thoroughly through timely, open-ended enquiries, active listening, and ongoing feedback (Telang, 2014). HB-PBL enhances this by linking learning to real-world circumstances, rendering it more significant than merely abstract future relevance (Johansen et al., 2023). It prompts students to assess their health risks and recognise preventative behaviours, so rendering learning more individualised and captivating. When social impacts are examined, students engage more intimately with the content, hence enhancing their active engagement (Wiley & Cory, 2013). Consequently, their cognition progresses from fundamental comprehension to advanced reasoning (Amanda et al., 2022).

CONCLUSION

This study concludes that HB-PBL has a significant positive effect on students' cognitive learning outcomes and critical thinking skills ($p < 0.05$). Students instructed with the HB-PBL method attained higher cognitive performance and greater improvement in critical thinking compared to those who received conventional instruction. Rooted in the health belief model, HB-PBL utilises students' beliefs of health risks to enhance engagement and promote critical thinking. These findings suggest that integrating health-based constructs not only supports academic development but also promotes students' health awareness and the adoption of healthier practices. The findings of this study also have important implications for educational practice and the development of science education. This application of HB within PBL frameworks extends the theoretical foundation of science pedagogy by demonstrating how psychological and health behavior theories can be operationalized to support scientific reasoning and critical thinking. Future research is recommended to further examine the role of health attitudes in shaping students' learning behaviors across diverse educational contexts.

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