



Systematic Literature Review: Implementation of the Challenge Based Learning (CBL) Model in Science Learning

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Abstract: This study aims to conduct a systematic literature review through a Systematic Literature Review regarding the application of the Challenge Based Learning (CBL) model in Natural Science (IPA) learning. CBL is a pedagogical approach that involves students in solving real-world challenges, encouraging active learning, collaboration, and the development of 21st-century skills. The method used in this study is a Systematic Literature Review (SLR) using the PRISMA technique with keywords namely Challenge Based Learning (CBL), 21st-Century Skills, and Science Learning. The inclusion criteria of this study are articles discussing the CBL learning model, elementary, junior high, and high school education levels, full-text access, original research (development, qualitative, quantitative, and CAR), published within the 2020-2025 range (the last 5 years), while the exclusion criteria are articles outside the inclusion criteria. By analyzing relevant literature, this study identifies the characteristics, effectiveness, and challenges in implementing CBL in science learning at various levels of education. The review results indicate that CBL has great potential to improve students' learning motivation, conceptual understanding, critical thinking skills, and problem-solving abilities in science. However, CBL implementation also faces several obstacles, such as the need for thorough teacher preparation, resource availability, and relevant challenge design. The implications of this research are expected to provide guidance for educators, researchers, and curriculum developers in effectively integrating CBL into science learning.

Keywords: Challenge Based Learning (CBL); Science learning; 21st century skills

Introduction

Science learning in the modern era demands an approach that focuses not only on knowledge transfer but also on developing critical thinking, creativity, collaboration, and problem-solving skills. Traditional teacher-centered learning paradigms often fail to facilitate the achievement of these goals (Martin-Alguacil et al., 2024; Katawazai, 2021). Therefore, innovations in learning models that actively and contextually engage students are needed (Huang, 2025; Oke & Fernandes, 2020). One learning model gaining attention is Challenge-Based Learning (CBL). CBL is a pedagogical framework that challenges students to develop solutions to complex, real-world problems or challenges (Galdames-Calderón et al., 2024; Helker et al.,

2025). In CBL, students work collaboratively to identify problems, conduct research, develop ideas, and implement solutions (Le et al., 2018; Albay, 2019). This approach aligns with the principles of constructivism and inquiry-based learning, which emphasize students' active role in constructing their own knowledge. Science learning in Indonesia often focuses on memorization and underemphasizes conceptual understanding and critical thinking skills (Pahrudin et al., 2021). This results in students having difficulty applying science knowledge to their daily lives and lacking motivation to learn.

To address these issues, innovative and effective learning approaches are needed, one of which is Challenge-Based Learning (CBL). CBL is a student-centered learning model, in which students are

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confronted with real-life challenges or problems relevant to their lives (Gutiérrez-Martínez et al., 2021; Castro & Zermeño, 2020). Through this problem-solving process, students are expected to develop critical thinking, creativity, collaboration, and communication skills. The application of CBL in science learning has the potential to improve students' conceptual understanding, science process skills, and learning motivation (Saifi et al., 2024; Dewi et al., 2022; Kundera et al., 2025). Although CBL has been widely applied in various fields of study, its application in science learning holds particular potential given the empirical and problem-solving-oriented nature of science (Gudonienė et al., 2021; Wardani et al., 2023; Michel & Neumann, 2016). Previous studies have shown that CBL can improve student engagement, understanding of scientific concepts, and science process skills (Dori et al., 2018; Chengere et al., 2025; Dah et al., 2024).

However, there has been no comprehensive systematic review of how CBL is applied in specific science learning contexts, including its effectiveness, challenges, and implementation recommendations. Therefore, this study asks the following research questions: What are the characteristics of the application of the CBL model in science learning?; How effective is the application of the CBL model on student learning outcomes and skills in science learning?; What are the challenges and opportunities in implementing the CBL model in science learning?

Method

The research method used was a systematic literature review (SLR). The SLR method systematically identifies, selects, and critically evaluates relevant research, then comprehensively analyzes and interprets the research to answer the stated research questions (Collins et al., 2021). The stages of this SLR research employ the PRISMA technique, which stands for Preferred, Reporting, Items for System Reviews, and Meta-Analysis. These steps include: posing a research question; finding; critically evaluating studies; collecting data; analyzing and reporting data; interpreting findings; and refining and updating the review (Reed et al., 2021). However, in this study, the steps used extend up to the fifth stage. The research steps are carried out in stages, including:

Posting Research Questions

Creating research questions that will be the focus of the research discussion. The research questions are: What are the characteristics of implementing the CBL model in science learning?; What is the effectiveness of implementing the CBL model on student learning outcomes and skills in science learning?; What are the

challenges and opportunities in implementing the CBL model in science learning?

Finding

The second stage involves searching for or discovering studies using the Crossref database. This database is obtained using the publish-of-perish application and searching for journal titles in the Crossref database. Next, a search criterion is used to find articles that meet the required criteria. This study used three keywords: Challenge-Based Learning (CBL), 21st Century Skills, and Science Learning to generate the database for the study. Using these criteria, 1,000 articles were found, spanning the period from 2020 to 2025 (the last five years).

Critical Evaluation of the Study

In the third stage, after obtaining 1,000 article titles, a critical evaluation of the articles was conducted to ensure they were on target. This evaluation was separated based on criteria to systematically determine boundaries. The criteria used were inclusion criteria for articles to be studied and exclusion criteria for articles not studied. These criteria can be seen in the following table.

Table 1. Article inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles discussing the CBL learning model	Articles that do not discuss the CBL learning model
Elementary, Middle, and High School Education Levels	University-level articles
Full text accessible, Original research (development, qualitative, quantitative, PTK)	Full text inaccessible, Literature study research, books
Published in the period 2020-2025 (last 5 years)	Published before 2020

Data Collection

The fourth stage involved collecting data from articles screened and adjusting them to the inclusion and exclusion criteria. Based on these criteria, 11 articles were used: those that met the inclusion criteria and 989 articles that did not meet the research criteria.

Analyzing Data Reporting

In the fifth stage, researchers analyzed the articles identified in accordance with the research questions from the initial stage. First, an analysis was conducted based on the article titles. Titles that did not discuss or relate to the CBL model and science learning were immediately excluded and not used. Out of 1,000 articles, 273 met the inclusion criteria. Next, an analysis was conducted by reading the abstracts, checking the level, full-text access permission, and research type, resulting in 35 articles. Finally, an analysis was conducted based on reading the entire article, resulting

in 11 articles that met the research title. The results of this multi-stage process resulted in 11 articles that will be analyzed and reported. The systematized Systematic

Literature Review (SLR) stage scheme uses the PRISMA table, as shown in Figure 1, which illustrates the stages in data extraction.

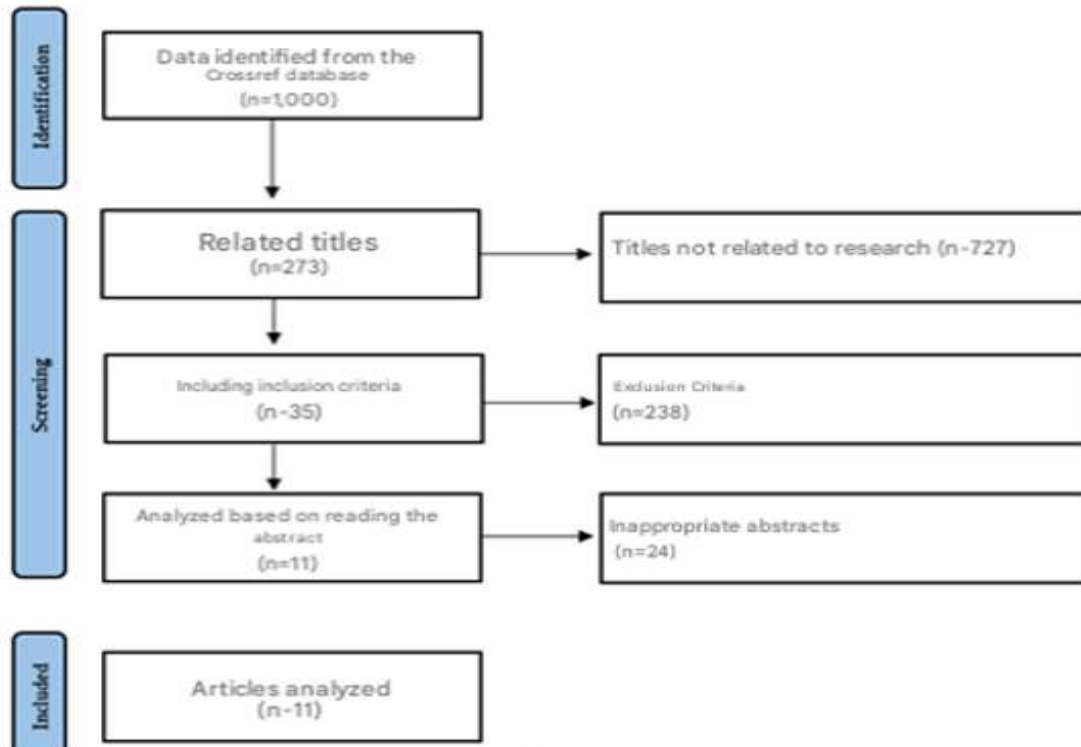


Figure 1. PRISMA flowchart analysis

Results and Discussion

A systematic literature review is conducted by identifying, selecting, and critically evaluating relevant research, then thoroughly analyzing and interpreting it

to answer the research question. The literature used has been identified, selected, and assessed, and deemed relevant. The following are the results of the analysis of 11 articles that met the inclusion criteria and were relevant to this study.

Table 2. Article review results

Author and Year	Article title	Research Results
Aimena Salma Khumaira, Hadi Nasbey, Dwi Susanti (2024)	LKPD Berbasis Model Pembelajaran Challenge-Based Learning Terintegrasi STEM pada Materi Pemanasan Global	Challenge-Based Learning (LKPD) can be implemented in physics learning activities as supporting teaching materials. It is expected to help students understand global warming and increase student awareness of preventing and reducing carbon emissions that cause global warming.
Fairazatunnisa, Gelar Dwirahayu, Eva Musyirifah (2021)	Challenge Based Learning dalam Meningkatkan Kemampuan Berpikir Kreatif Siswa pada Materi Persamaan Linear Satu Variabel	The results showed that students' mathematical creative thinking skills in the Challenge-Based Learning model were higher than those in conventional learning. Specifically, the indicator of mathematical creative thinking ability that achieved the highest score was elaboration.
Sitti Rahma, Muhajir, Suardi (2024)	The Impact of Media Card Match Circle and the Challenge Based Learning (CBL) Learning Model on the Learning Outcomes of Pancasila Education in Elementary School Students	The analysis showed that the implementation of the CBL model with Card Match Circle media significantly improved student learning outcomes compared to conventional teaching methods, with the average post-test score for the experimental group (80.37) higher than the control group (72.41).

Author and Year	Article title	Research Results
Nur Hafidh Ash-Showy, Adi Satrio Ardiansyah, Muhammad Ainun Niam, Sumarti, Nurul Qomari (2022)	Pengembangan Bahan Ajar Perbandingan Terintegrasi Challenge Based Learning dengan Pendekatan STEM terhadap Kemampuan Berpikir Kritis Siswa	The development of integrated Challenge-Based Learning teaching materials with a STEM approach is feasible for developing students' critical thinking skills and can be implemented in learning activities for seventh-grade junior high school students.
Nanda Anugrah (2024)	Pengaruh Model Pembelajaran Challenge-Based Learning (CBL) Berbantuan E-Learning Quizizz Terhadap Kemampuan Berpikir Kritis Matematis Siswa	The results of the study revealed that the mathematical critical thinking skills of students taught using the Challenge-Based Learning model assisted by the Quizizz e-Learning program were higher than those taught using the conventional learning model ($\alpha = 135.5$ and a p-value of $0.000 < 0.05$).
Syifa Nailufar Rohman (2021)	Pengaruh Model Challenge Based Learning Terhadap Kemampuan Berpikir Kritis Siswa pada Konsep Pemanasan Global	The results showed that the Challenge-Based Learning model had an impact on students' critical thinking skills. Students' critical thinking skills in the experimental class increased more (N-gain of 0.616, in the moderate category) than those in the control class (N-gain of 0.487, in the moderate category).
Puput Stefani, Vidya Setyaningrum (2024)	Pengaruh Penerapan Model Challenge Based Learning terhadap Keterampilan Komunikasi Peserta Didik pada Materi Bunyi dan Sifatnya Kelas V Sekolah Dasar	The results showed that the Challenge-Based Learning model had a significant impact on students' communication skills regarding sound and its properties. This was influenced by their understanding, the ability to collaborate between teacher and students, and the use of learning media.
Nanda Hamidah Kusumaningtya, Rusnilawati (2025)	Model Challenge Based Learning berbasis Kahoot: Strategi Meningkatkan Kemampuan Berpikir Kritis Siswa pada Mata Pelajaran IPA Kelas IV Sekolah Dasar	The results showed that the critical thinking skills of the two classes differed significantly in a positive way. The Challenge-Based Learning approach, combined with the Kahoot medium, enhances elementary education by fostering teamwork, learning dynamics, and students' capacity for critical thinking.
Desy Dwi Riyanti, Ana Fitrotun Nisa (2024)	Implementasi Model Pembelajaran Berbasis Masalah dalam Pembelajaran IPA Kelas IV SDN Pelret Kidul	The results of this study indicate that the implementation of the problem-based learning model in fourth-grade science at Pleret Kidul Public Elementary School is a learning model applied by teachers, creating enjoyable learning.
Riskawati, Meri Hariratul Jannah, Nurasmita, Sherly (2021)	Pengaruh Challenge Based Learning (CBL) Terhadap Kemampuan Literasi Informasi dan Literasi Sains pada Siswa Kelas XI SMAN 9 Jeneponto	The results indicate that the improvement in science literacy skills with CBL is still classified as moderate, with a score of 55.87, and the improvement in information literacy skills with CBL is still classified as moderate, with a score of 66.61.
Ahmed Sardi, Palimari, Sitti Rahmayani (2022)	Peningkatkan Kemampuan Berfikir Kritis Siswa melalui Challenge Based Learning	The results of this study indicate that : the use of the CBL learning model can improve students' critical thinking skills; there was an increase in the percentage of student activity from 61.18% in Cycle I to 84.21% in Cycle II; there was an increase in students' cognitive learning outcomes from Cycle I to Cycle II when learning using the CBL learning model.

Based on the discussion of all the articles analyzed, results were obtained regarding the characteristics, effectiveness, and challenges likely to be faced in implementing the CBL model in science learning. The Challenge-Based Learning model is a learning approach that involves students in identifying real-world challenges, then designing and implementing concrete solutions to overcome them. This learning model, which combines problem-based learning, project-based learning, and contextual learning, focuses on solving problems in everyday life, thereby creating space for

students to think creatively, critically, and actively in finding solutions to existing challenges. Students who engage in the learning process assisted by Challenge-Based Learning are guided to think rationally, critically, and creatively, as well as to develop a strong curiosity about science, communication and collaboration skills, honesty, consistency, and resilience in facing real-life problems (Daff et al., 2024; Ibn-Mohammed et al., 2024; Lee & Hancock, 2023).

The application of the CBL model in science learning has several characteristics, such as:

emphasizing active student involvement in the learning process (Helker et al., 2025; Taconis & Bekker, 2023). Students are not merely passive recipients of information but also solution-finders and decision-makers; Learning begins by presenting real, relevant problems or challenges to students' lives (Darling-Hammond et al., 2020; Wijnia et al., 2024). These problems are typically complex and lack a single, easy solution; Students work in groups to solve the problem or challenge. This collaboration fosters the development of communication, cooperation, and leadership skills; Students often engage in projects to solve the problem or challenge. These projects can take the form of presentations, product creation, or other activities that demonstrate students' understanding of the concepts being learned; The problems or challenges presented are

relevant to students' real-life contexts, thus increasing their motivation and understanding; The CBL framework is flexible and can be adapted to students' needs and the learning context.

Reiterating that the CBL model combines problem-based learning, project-based learning, and contextual learning, focused on solving everyday problems, some characteristics and syntax are similar. However, what distinguishes the CBL model from other models is its focus on solving complex, open-ended challenges and a more flexible structure. If implemented properly, the CBL model has the potential to significantly improve student learning outcomes and skills in science learning. The following graph shows the application of CBL in several dependent variables studied based on the articles analyzed (Maia et al., 2023; McLean, 2016).

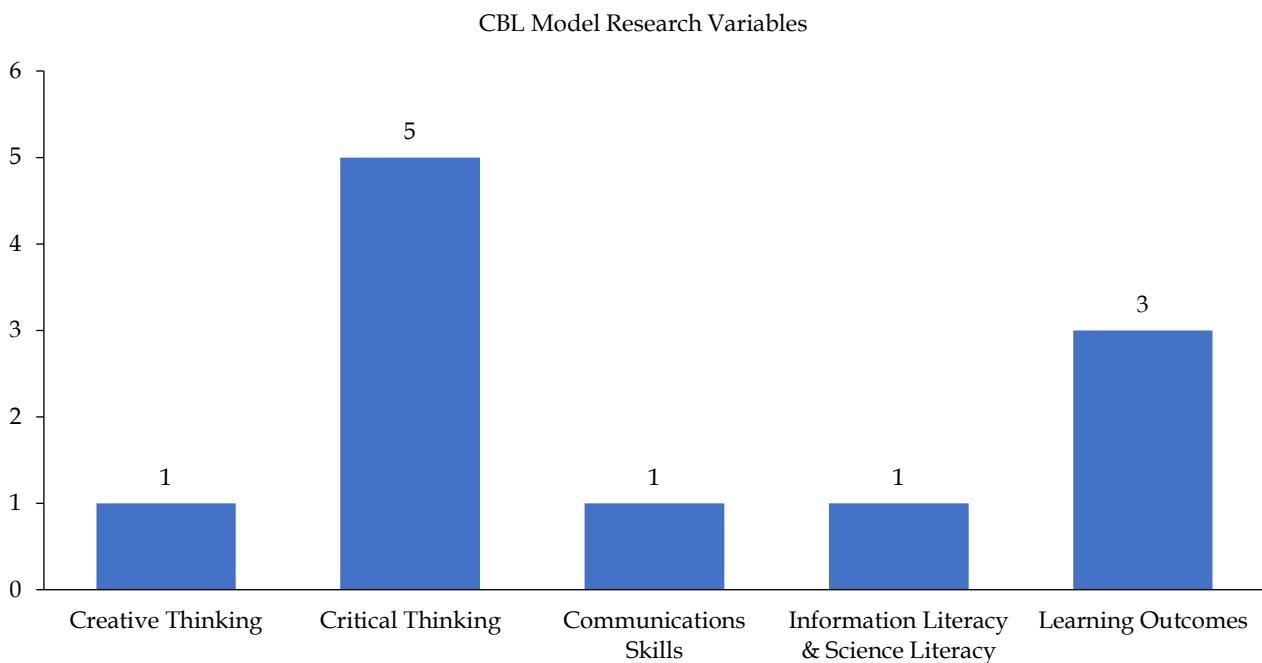


Figure 2. Research variables for the CBL model

Analysis of several articles using the CBL model indicates that CBL encourages students to deeply understand science concepts through solving complex, real-life challenges (Beemt et al., 2023). Over the past five years, there has been one article examining CBL's role in improving creative thinking, five articles on improving creative thinking, one article on improving communication skills, one article on improving information literacy and science literacy, and three articles on improving student learning outcomes (Jannah et al., 2025). The research findings indicate that the implementation of CBL is highly effective in the learning process. This is evident in students' active involvement in the problem-solving process. Students not only memorize facts but also build more meaningful

and lasting understanding (Byusa et al., 2022; Rehman et al., 2024). CBL requires students to analyze information, evaluate evidence, and make decisions based on logical reasoning. This process fosters critical thinking skills, which are crucial, especially in science. Therefore, CBL directly trains students' problem-solving skills by facing complex and unstructured challenges, requiring students to develop effective and creative problem-solving strategies (Rehman et al., 2024; Hanani, 2020).

The problem-solving process is also collaborative, requiring students to interact and communicate with their peers. This improves communication and collaboration skills, making the learning environment more engaging and motivating for students (Baucal et al., 2023; Aslan et al., 2025). The Challenge-Based

Learning model trains students to formulate, research, and analyze problems (Isbadriantingtyas et al., 2024; Paraniti et al., 2024). Applying academic knowledge to real-world problems enhances students' problem-solving abilities (Zhang et al., 2025). This learning process, which focuses on informed decision-making, hones critical thinking skills. CBL includes the following stages (Listiana et al., 2023): main idea, key questions, challenges, guiding questions, activities, learning resources, solutions, assessments, and publications. Students are actively engaged in discovering, investigating, and solving challenges that are relevant to real life and designed to motivate them to learn. These challenges encourage students' independence, creativity, and innovation throughout the inquiry process, from identifying problems to formulating solutions (Xu et al., 2024).

The Challenge-Based Learning model is a new learning model that combines problem-based learning, project-based learning, and contextual learning, focused on solving problems in everyday life (Fairazatunnisa et al., 2021). Despite its effectiveness, CBL implementation is not without challenges, such as requiring teachers' creativity to design authentic challenges that are appropriate to students' developmental levels. Some challenges may require access to specific tools, materials, or technology, and CBL often takes longer than traditional learning models (Roca, 2022; Rådberg et al., 2020). Teachers act as facilitators and mentors, not simply providers of information, which requires pedagogical adaptations (Onrubia et al., 2022; Hennessy et al., 2022). Furthermore, assessing the process and product in CBL can be more complex than other conventional assessments (Vasquez-Lopez et al., 2024; Desveaud et al., 2024).

Conclusion

The Challenge-Based Learning model is a learning approach that involves students in identifying real-world challenges, then designing and implementing concrete solutions to overcome them. The implementation of CBL is very effective in the learning process, as seen in students who are actively involved in the problem-solving process, students not only memorize facts, but also build a more meaningful and lasting understanding. CBL requires students to analyze information, evaluate evidence, and make decisions based on logical reasons. This process trains critical thinking skills that are very important, especially in science. The challenges in implementing CBL going forward are that it requires teacher creativity to design authentic challenges that are appropriate to the developmental level of students, requires access to certain tools, materials, or technology, and CBL often

takes longer than traditional learning models. Teachers are also required to act as facilitators and mentors, and assessment of the process and product in CBL can be more complex than other conventional assessments.

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Author Contributions

Conceptualization; methodology.; validation; formal analysis; investigation; resources; N.K.J.; data curation: writing—original draft preparation; writing—review and editing.; visualization, I.W.R. and I.N.T. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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