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Exploration of Constructivist Learning Models in Developing Critical Thinking Skills: A Systematic Literature Review

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ABSTRACT

This study aims to explore various constructivist learning models through a systematic literature review, focusing on the characteristics, advantages, disadvantages, and potential combinations of models to develop learners' critical thinking skills. The paper conducted a systematic literature review of 30 empirical articles published between 2015-2024 to explore constructivist learning models and their impact on critical thinking development. We identified five constructivist learning models; Problem-Based Learning (PBL), Project-Based Learning (PjBL), Inquiry-Based Learning (IBL), Cooperative Learning (CL), and Discovery Learning (DL) that have a significant impact on developing critical thinking skills through active interaction, problem-solving, and collaboration. PBL is considered the most effective model for developing critical thinking skills, followed by PjBL and IBL, which emphasize cooperation and experimentation. Meanwhile, CL strongly supports the process of discussion and critical reflection in groups, and DL provides space for learners to discover knowledge independently through personal exploration. We recommend that educators choose models that are appropriate to the learning context: PBL and PjBL for collaborative problem solving, IBL for independent exploration, CL for group discussion, and DL for independent knowledge discovery.

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1. INTRODUCTION

Individuals in the era of rapid information dissemination are expected to master 21st-century skills in order to adapt effectively (Altun & Yildirim, 2023). These skills allow individuals to filter the information obtained and separate between personal opinions and proven facts (Thornhill-Miller et al., 2023). Thus finding a relevant place in society, making informed decisions, being productive, and living a meaningful life (Çiftçi et al., 2021). To succeed at work and in 21st-century society, individuals need

a combination of *soft skills* and character traits that include learning skills (creativity, critical thinking, communication), literacy skills (information literacy, media, and information and communication technology), and life skills (flexibility, initiative, social skills, productivity, and leadership) (González-Pérez & Ramírez-Montoya, 2022; Kennedy & Sundberg, 2020). These skills are essential for navigating the fast-paced environment that characterizes this era (Chiva Long et al., 2024).

One of the skills included in the learning and innovation skills category is critical thinking. This skill is considered one of the main competencies that are essential for success in academic and career fields (Akbarilakeh et al., 2018; Evans, 2020). Critical thinking refers to mental and intellectual abilities that are directed at analyzing and evaluating existing communications, information, and arguments, primarily through the use of logic and reason (Akpur, 2020). Critical thinking is also understood as a higher-order cognitive process that focuses on an individual's ability to understand problems in depth and design effective solutions (Li et al., 2024). This skill plays a crucial role in the process of logical reasoning, efficient decision-making, and systematic problem-solving (Haber, 2020). Weak critical thinking skills are often the cause of individuals making poor decisions (Pshembayeva et al., 2022).

Critical thinking is widely regarded as an essential skill in the 21st century and has been a concern in education for a long time. (Akbar, 2023; ŽivkoviĿ, 2016). In the last decade, education in Indonesia has undergone a significant transformation in learning orientation from *a teacher-centered* to a *student-centered* approach. This paradigmatic shift reflects the need to improve the quality of learning and learners' global competitiveness. (Tang, 2023). However, the results of the *Programme for International Student Assessment* (PISA) study in 2022 showed that Indonesian learners' ability to analyze information, solve complex problems, and think critically ranked 65 out of 81 countries (OCDE, 2023). Similar findings were also seen in the *Trends in International Mathematics and Science Study* (TIMSS) in 2019; the scores of Indonesian students were still below the average score, and the majority of students had difficulty solving problems that required complex analysis, application of theory in new situations and multi-step problem-solving. (Mullis et al., 2020). The results of this study illustrate that higher-order thinking skills are still a significant problem in Indonesian education.

The implementation of the Merdeka curriculum is an effort to respond to modern learning needs by emphasizing the development of 21st-century skills. (Zulhadi & Susanto, 2024). This curriculum aims to equip students to become lifelong learners whom Pancasila characterizes as faith, devotion to God Almighty, noble character, cooperation, critical reasoning, global diversity, independence, and creativity. (Wahyudin et al., 2024). The Merdeka curriculum provides learners freedom in learning, integrating technology, project-based, and problem-based learning to adapt to individual needs and contemporary demands. (Shadri et al., 2023). However, the development of learners' critical thinking skills still faces various challenges (Tumanggor, 2021). Several empirical studies show that although learning approaches have been more learner-centered, learning outcomes related to critical thinking still need to be fully optimized.

Previous studies consistently show the low critical thinking skills of Indonesian students. A study by Amin et al. (2017) identified low critical thinking skills among learners, while the findings of Sari et al. (2021) reinforce these results through field observations that show that many students still need to achieve optimization in critical thinking. Research Sarwanto et al. (2021) mentioned that internal factors from students' and educators' learning approaches are the leading causes of low critical thinking skills. Setiawan et al. (2023) also confirmed that students' higher-level thinking skills are still in the low category, in line with previous findings. Wardani et al. (2024) added that the score of critical thinking skills in conventional learning only reached 52.80%. Consistent findings from various studies in different periods indicate that this low critical thinking ability is a systemic and widespread problem in the Indonesian education system.

Constructivist theory is one of the potential approaches to improve learners' thinking skills. (Almulla, 2023; Ghaedi et al., 2020). The main idea of constructivist theory is that meaningful knowledge and critical thinking are actively constructed, whether cognitively, culturally, emotionally, or socially (Zajda, 2021). This process occurs through interaction with the environment and through

meaningful learning experiences (Murtazoevna, 2024). Constructivism-based learning is an active process that involves active interaction between learners, educators, and other components. (Saleem et al., 2021). This approach also encourages collaboration and knowledge exploration (Lee et al., 2024; Yeh et al., 2024). The constructivist learning base is applied through various learning models, such as *Problem-Based Learning* (PBL) (Liu et al., 2024; Schmidt et al., 2019), *Inquiry-Based Learning* (IBL) (Perdana & Atmojo, 2019; Zajda, 2022), *discovery learning* (Muhammad et al., 2023), *collaborative learning* (Zhu et al., 2024), and *Project-Based Learning* (PJBL). (Mitry, 2021; Wang et al., 2023). All of these models refer to the principles of constructivism (Renninger, 2024). However, each has its characteristics in encouraging the active involvement of students in developing critical thinking skills (Chu et al., 2021; Nagarajan & Overton, 2019).

Constructivism-based learning models have shown their effectiveness in various studies in developed countries. PBL is designed to lead learners to think critically, solve problems, synthesize, and build understanding through unstructured problems. (Dabbagh, 2019). Meanwhile, *collaborative learning* aims to develop learners' skills of cooperation, communication, and social responsibility (Qureshi et al., 2023). IBL allows learners to ask questions, formulate hypotheses, and conduct in-depth investigations, thus encouraging the development of analytical and evaluative thinking (Chikaluma et al., 2022). *Discovery learning* is designed to mold learners into active thinkers and independent learners (Nusantari et al., 2021). On the other hand, PJBL is effective in developing learners' thinking skills, social skills, and collaboration skills (Chen et al., 2022; Sasson et al., 2018).

The application of constructivist learning models in educational contexts has been widely discussed in various systematic literature studies. However, these literature studies focus on one particular constructivist *learning* model, such as PBL or IBL. Research that comprehensively compares or explores the integration of multiple models is still being determined. As a result, a holistic understanding of how these models can complement each other in supporting learning is limited. In addition, previous research tends to evaluate the effectiveness of existing models without providing an adequate empirical basis for the development of new, more innovative models. Therefore, research that integrates the exploration of various learning models is needed to create new approaches that are more relevant to the needs of learners in the modern era.

The urgency of this research is reinforced by education policy in Indonesia, which emphasizes the importance of developing critical thinking skills as one of the core competencies that students must achieve. (Irwan et al., 2024). Merdeka Belajar's policy encourages the use of a more learner-centered learning approach, with an emphasis on active, collaborative, and project-based learning. (Kemendikbudristek, 2021). This approach is aligned with the principles of constructivism, where learners are encouraged to construct their knowledge through interaction with a supportive learning environment (Le & Nguyen, 2024). Given the importance of critical thinking development in achieving curriculum objectives, this research is relevant to conduct.

Our paper aims to (1) identify constructivist learning models that are effective in developing students' critical thinking skills (RQ1), (2) analyze how each constructivist learning model is implemented in the classroom, as well as how each model facilitates the development of students' critical thinking (RQ2), and (3) evaluate the advantages and disadvantages of each constructivist learning model in the context of developing students' critical thinking skills (RQ3). Through a systematic literature review, more profound insights into the effectiveness and challenges of various existing constructivist learning models can be found, as well as recommendations for better educational practices in promoting students' critical thinking skills.

2. METHODS

This research uses the *Systematic Literature Review* (SLR) method, which is a structured method for reviewing existing research evidence. (Arvanitis, 2024) by systematically identifying, evaluating, and synthesizing all available studies on a particular topic (Tomczyk et al., 2024). This method involves thoroughly collecting relevant studies and summarizing the findings using a standardized and

reproducible approach. The main objective of using SLR is to minimize potential bias, resulting in more accurate and reliable conclusions (Brignardello-Petersen et al., 2024; Ofori-Boateng et al., 2024)

This SLR uses a structured approach based on the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) protocol to increase transparency and completeness of reporting in systematic reviews. (Mohamed Shaffril et al., 2021; Pati & Lorusso, 2018). The PRISMA protocol is a widely recognized framework for conducting systematic literature reviews (SLRs), which ensures transparency and reproducibility. (Susnjak, 2023). The protocol involves several stages, including identification, screening, and inclusion, which are essential for systematically reviewing the literature. This approach aims to explore the literature related to constructivist learning models that are relevant to developing critical thinking skills. Our protocol consists of three stages, namely *identification, screening, and inclusion*. It is briefly presented in the form of a PRISMA *Flow Diagram* in Figure 1.

Identification Stage

A systematic review begins with the literature identification stage, which is the stage of determining the focus, research questions, types of sources, quality of sources, search mechanisms, periods, and keywords. (Karunarathna et al., 2024). This study focused on comprehensively reviewing journal articles on the grounds that the review process on journal articles is more rigorous than other academic sources such as books, book chapters, conference proceedings, dissertations or theses, review articles, and so on. (MacDonald et al., 2024) Next, we determined the search mechanism, period, and keywords. This review used a Scopus search to extract literature relevant to the field of study.

Research articles published from 2015 to 2024 were retrieved for this review, written in English, and available with full open access. The keywords developed to review empirical research on our research focus were (TITLE-ABS-KEY *("Critical Thinking" AND ("Problem-Based Learning" OR "Inquiry-Based Learning" OR "Inquiry-Based Learning" OR "Project-Based Learning" OR "Collaborative Learning" OR "Discovery Learning")).* The keywords we used are combination keywords adjusted to the focus of our research, which is exploring constructivist learning models to develop critical thinking skills. Based on the literature search on November 04, 2024, we found 336 papers.

Screening Stage

The next step in the preparation of this SLR is filtering or refining the journal articles found. The filtering stage involves the identification of documents from the adopted database resulting from the identification stage of the search conducted (Marzi et al., 2024), Moreover, using predefined criteria (Ye et al., 2024). These criteria are essential in distilling a large number of initial studies into a manageable and relevant subset for detailed analysis. (Cooper et al., 2019).

The literature screening process in this SLR followed the inclusion and exclusion criteria, which was done in two steps, namely;

Step one: We applied filters to find articles that matched the research focus. We limited the subject areas to social sciences and education. Document type and source were limited to journal articles; papers published in non-journal academic forms, such as editorials, book reviews, or short reports, were also excluded as they did not meet the scientific research standards required for this review. After applying this filter, we found 162 articles.

Step two: From the 162 articles that passed the initial screening stage, we conducted further screening by reviewing the titles and abstracts. The selected articles had to address constructivist learning models in the context of developing learners' critical thinking skills at secondary and higher education levels in the field of social science studies. We limited empirical research to experimental methods, so theoretical studies, systematic reviews, meta-analyses, and developmental studies were excluded from our review. Articles that were not supported by empirical data or that did not focus on constructivist learning models were also excluded due to their incompatibility with the research questions, resulting in only 58 articles being included in the next stage.

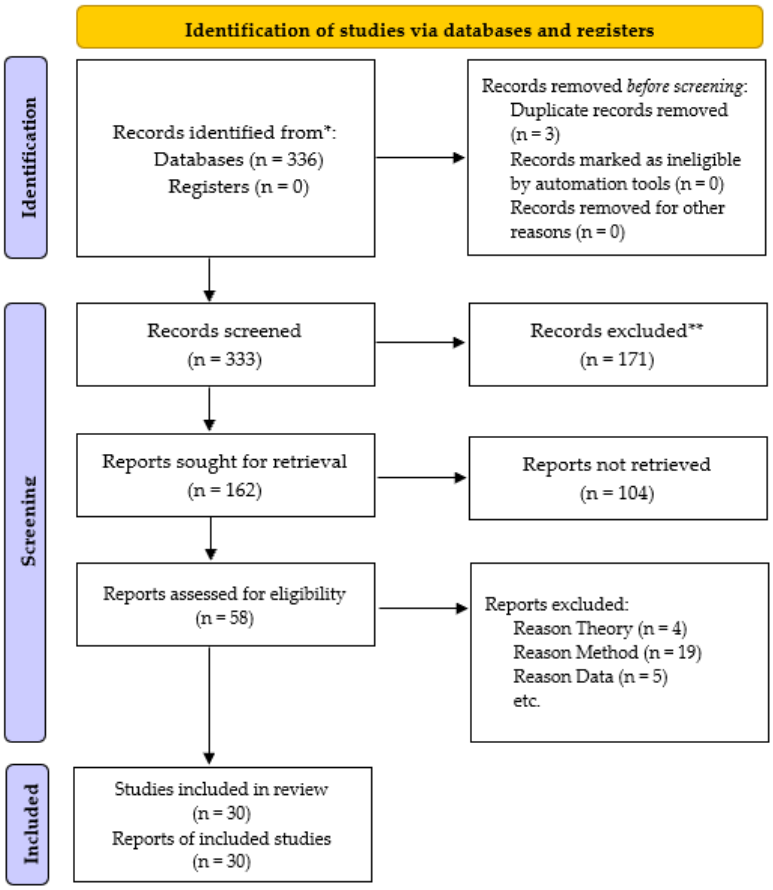
Eligibility stage

The next step after the screening stage is the *full-text* evaluation or eligibility testing stage, *where* the analysis is conducted in-depth through a thorough reading to ensure that the article meets the

inclusion criteria. (Toronto & Remington, 2020). Experimental research must clearly state the experimental design and at least one comparison/control class. Even if an article adds other variables to the experimental design, we are not concerned. Articles will be excluded from this review if they do not explicitly include measurement or discussion of the development of critical thinking skills. With the elimination of the full text of the articles, we decided on 30 articles that were included in the systematic review.

Included Stage

The *included* stage in the *Systematic Literature Review* (SLR) process based on the PRISMA protocol involved the final selection of articles that met the inclusion criteria after a rigorous screening stage. Of the total articles screened, 30 articles were selected and deemed relevant for further analysis. These articles underwent an in-depth evaluation, including examination of the title, abstract, and full content, to ensure that they met the research objectives and methodological criteria. This stage marked the end of the selection process and the beginning of systematic data analysis.



PRISMA Flow Diagram
Source: (Haddaway et al., 2022)

Data analysis techniques on the selected articles used a thematic approach to identify the main patterns relevant to the research. This analysis focused on three main aspects, namely identifying the type of constructivist learning model used, identifying the syntax of the application as well as the role of educators and learners in the classroom of each model, and comparing the effectiveness or implementation of these models in developing critical thinking. The results of the thematic analysis are presented in the form of descriptive narratives that describe the main findings of the reviewed literature, thus providing a comprehensive understanding of constructivist learning models to develop critical thinking.

3. FINDINGS AND DISCUSSION

Critical thinking involves the ability to analyze information in depth, evaluate multiple perspectives, and make decisions that are based on logical arguments and solid evidence (Alsaleh, 2020). These critical thinking skills are critical in the context of education because learners not only need to master the material but also need to be able to think reflectively and analytically in dealing with problems (Erdogan, 2019).

The constructivist learning model focuses on the active construction of knowledge by learners. (Al Abri et al., 2024)Constructivist learning models focus on active knowledge construction by learners, providing opportunities for learners to explore authentic, real-world problems, engage in meaningful inquiry, and construct knowledge (Chabeli et al., 2021). This literature review aims to explore how constructivist learning models can contribute to developing learners' critical thinking skills.

Three research questions were formulated in this review, namely;

RQ1. What are some constructivist learning models that are effective in developing students' critical thinking skills?

RQ2. How is each constructivist learning model implemented in the classroom?

RQ3. What are the advantages and disadvantages of each constructivist learning model in the context of critical thinking?

This research aims to provide an understanding of the diversity of constructivist learning models, how they are applied in educational settings, and how each model can contribute to developing learners' critical thinking skills. In addition, this research also identifies the advantages and disadvantages of each model in the context of developing critical thinking. The findings are expected to guide educators in choosing and implementing the right learning model according to their needs and classroom context.

Effective Constructivist Learning Model in Developing Critical Thinking (RQ1)

Based on the analysis of 30 articles examining the application of constructivist learning models, five main models were found to be frequently used. Namely, *Problem-Based Learning* (PBL) dominated the literature with eleven references, *Project-Based Learning* (PjBL) recorded eight references, *Inquiry-Based Learning* (IBL) with five references, *and Collaborative Learning* (CL) and *Discovery Learning* (DL) with three references each.

Problem-Based Learning (PBL)

PBL is the most discussed constructivist model in the analyzed literature, with 11 (table 1) articles discussing its application. This model has been shown to be effective in developing critical thinking skills (CTS), as it encourages learners to be directly involved in solving real-world problems (Benedicto & Andrade, 2022). Fadilla (2021) Suggests that learning models that are identical to actively involving students tend to encourage students to develop critical thinking skills.

Table 1. Methodology and Research Results of the PBL model

Reference	Duration Treatment	Number of Participants	CTS Instrument	Research Results
Ding, (2016)	9 weeks	342	*Adapted California Critical Thinking Disposition Inventory*	PBL improved all critical thinking subscales, the most in Independent Inquiry. The gender difference in Group Negotiation at pre-test disappeared after the implementation of PBL.
Carbogim, et al., (2017)	3 weeks	102	Qualitative evaluation and	The intervention group showed more improvement in critical

Reference	Duration Treatment	Number of Participants	CTS Instrument	Research Results
			semi-structured interviews	thinking skills, such as analysis, evaluation, reflection, and organizing action.
Kumar, (2017)	6 weeks	60	Analytic Rubric	PBL improves learners' critical thinking skills in five writing categories: Audience, purpose, content, support, unity, and coherence.
Saputra et al. (2019)	3 weeks	37	Essay test C4 - C6 (Bloom's Taxonomy revised)	There is a significant increase in students' critical thinking skills after the application of the critical thinking model.
Yusuf et al., (2020)	8 weeks	70	Tests and questionnaires	After PBL treatment with the help of LBK media, the experimental group showed a higher average critical thinking ability than the control group.
Saputro et al., (2020)	4 weeks	2 classes	Essay Test	PBL is more effective in improving self-efficacy and critical thinking
Silviarza et al., (2020)	5 weeks	78	Test (Ennis Indicator)	There was an increase in critical thinking skills in the experimental class.
Amin et al., (2020)	-	50	Essay test (Ennis 1995 indicators)	There is a difference in critical thinking skills between the experimental and control classes. The average score increase in the experimental group is higher.
Suryanti & Nurhuda, (2021)	1 semester	41	Case study and essay test	PBL with an assessment rubric has the potential to improve critical thinking, but not significantly.
Hursen, (2021)	10 weeks	72	CT standardized test	The experimental group using Web 2.0-based PBL showed a more significant increase in critical thinking skills than the control group.
Orhan, (2024)	8 weeks	68	*Watson-glaser critical thinking test* and *Sosu critical thinking disposition scale*	Online and face-to-face PBL showed equal effectiveness in improving critical thinking skills. However, online PBL had a more significant effect size.

Source: Authors' elaboration, 2024

Table 1. outlines the results of the methodology and results analysis of 11 articles that examined the application of PBL to develop critical thinking skills. The treatment duration varied between 3 weeks to 1 semester, with the majority of studies having a duration between 3 to 8 weeks. The average treatment duration recorded was around 6 weeks, which suggests that the application of PBL within

this timeframe is practical enough to have a significant impact on improving critical thinking skills. The number of respondents also varied, ranging from 37 to 342 participants. The average number of respondents involved in each study was around 72 people. This diversity in the number of participants illustrates that PBL can be applied on various scales without reducing its effectiveness in developing critical thinking skills.

Most research results indicate that PBL can consistently improve critical thinking skills with a focus on analysis, evaluation, and more structured decision-making. PBL not only enriches learners' knowledge but also develops their ability to think independently, ask questions, and seek solutions critically. The use of technology also plays an important role in developing the effectiveness of PBL, such as LBK and Web 2.0 platforms, giving learners the opportunity to collaborate and access information more widely. These technologies not only increase interactivity in learning but also help learners think critically in more flexible and creative ways.

The success of PBL is greatly influenced by factors such as duration of implementation, quality of teaching, and technology integration. If implemented well, PBL can be a very effective model for developing the critical thinking skills that learners need to face challenges in an ever-evolving world.

Project-Based Learning (PjBL)

PjBL is also a topic that is widely discussed in the analyzed literature; eight articles examine its application. The idea of PjBL is to involve learners working in teams to investigate authentic problems, where the solutions found have the potential to be implemented in real life (Hussein, 2021). This process is very effective in developing critical thinking skills, as learners are faced with problems that require creative and practical solutions. Maryati et al. (2022) stated that PjBL develops learners' critical thinking skills by giving them space to make decisions and work relatively independently.

Table 2. Methodology and Research Results of the PjBL Model

Reference	Duration Treatment	Number of Participants	CTS Instrument	Research Results
Sasson et al., (2018)	2 years	Grade 9 and 10	Case-based questionnaire	There was no difference in critical thinking skills in the pre-test, but the innovative class improved more in the post-test after two years than the traditional class.
Adekantari, (2020)	4 weeks	72	Objective Test	The Instagram-assisted PjBL model affects students' critical thinking skills on indicators of focus, reasoning, conclusions, situation, clarity, and overall picture.
Sari & Prasetyo, (2021)	4 weeks	26	Descriptive test	On average, learners' critical thinking skills increased by 19%. The majority of learners agreed that PjBL helped develop critical thinking skills.
Cortázar et al., (2021)	1 semester	834	Written test	The experimental group that received social regulation scaffolding experienced more significant improvement. The feedback provided improved argumentation, analysis, and evaluation skills.

Reference	Duration Treatment	Number of Participants	CTS Instrument	Research Results
Listiqowati & Ruja, (2022)	2 months	30	Essay test (Ennis indicators)	The average post-test of the experimental group is higher, indicating that the PjBFC model is more effective in improving critical thinking skills than traditional PjBL.
Witarsa & Muhammad, (2023)	10 weeks	100	Written test	The experimental group experienced an increase in critical thinking skills at all ability levels. PjBL was also effective in developing critical analysis and problem-solving skills.
Hao, L. et al., (2024)	14 weeks	120	*Ennis-Weir Critical Thinking Test*	Both lessons improved critical thinking and creativity. However, PjBL flipped classroom is more effective than traditional learning.
Dias-Oliveira et al., (2024)	14 weeks	1156	*Self-Assessment of Reasoning Skills*	The experimental group showed an increase in critical thinking skills, especially in defining problems and induction ability.

Source: Authors' elaboration, 2024

Based on the results of the analysis presented in Table 2, the duration of treatment in the studies ranged from 4 to 14 weeks, with an average duration of about nine weeks. The study with the most significant number of participants involved 1,156 participants, while the smallest involved only 26 participants. The average number of participants in these studies was around 200. Although the number of participants varied, most of the studies involved relatively large experimental groups, with some reaching more than 100 participants.

The results showed an increase in critical thinking skills after treatment. Better improvement was recorded in the experimental group, both in terms of post-test scores and indicators of critical thinking skills. Most studies noted improvements in skills such as critical analysis, argumentation, problem definition, problem-solving, induction, and evaluation. Although the duration of the treatment and the number of participants varied, PjBL, with or without additional social regulation *scaffolding*, has excellent potential for developing learners' critical thinking skills.

Inquiry-Based Learning (IBL)

We found five articles that discuss the effectiveness of IBL in developing critical thinking skills. IBL adheres to the constructivist philosophy of learning, which states that knowledge is not passively received but instead actively constructed through individual and collaborative experiences (Solihabonu, 2024). Sam, (2024) revealed that IBL develops skills such as interpretation, analysis, evaluation, inference, explanation, and self-regulation, which are core components of critical thinking.

Table 3. Methodology and Research Results of the IBL model

Reference	Duration of Treatment	Number of Participants	CTS Instrument	Research Results
Arsal, (2017)	14 weeks	56	*California Critical Thinking Dispositions Inventory (CCTDI)*	There was no significant difference in critical thinking disposition. The experimental group showed an increase, but not significant, while the control group decreased slightly.

Reference	Duration of Treatment	Number of Participants	CTS Instrument	Research Results
Irwanto et al., (2018)	6 weeks	48	*Critical Thinking Essay Test* (CTET) Ennis indicators	The experimental group using POGIL showed significant improvements in CTS and PSS over the control group that followed traditional lectures.
Wale & Bishaw, (2020)	4 weeks	20	Essay test (Facione Indicator, 2015)	After participating in inquiry-based learning, students' critical thinking skills increased in the following areas: interpretation, analysis, evaluation, inference, explanation, and self-regulation.
Adnan et al., (2021)	4 weeks	31	Written test	The research showed a "moderate" improvement in the cognitive and critical thinking skills of students after the lesson,
Dewi, et al., (2021)	8 weeks	126	Written test	Both groups showed improvement in critical thinking, but the IBL group experienced better improvement, especially for learners with convergent learning styles.

Source: Authors' elaboration, 2024

Based on the data in Table 3, the treatment duration varied between 4 to 14 weeks, with an average of about 6 to 8 weeks. Most studies used a shorter duration, between 4 to 6 weeks, while a few others applied a longer duration. The number of participants also varied, with an average of about 48 people. Most studies involved a moderate number of participants, between 30 and 60 people.

The results showed an improvement in learners' critical thinking skills after participating in more active and interactive IBL learning. Overall, these results indicate that more participatory and inquiry-based learning tends to be more effective in developing learners' critical thinking skills.

Collaborative Learning (CL)

The CL model in this literature analysis, found in three articles, is a learning model that focuses on cooperation between learners, where they share knowledge, address social issues, and understand cultural differences to create innovative solutions together (Hidayah et al., 2024). This model has proven effective in encouraging critical thinking, as learners are invited to discuss, compare, and evaluate their ideas in groups. Kasimovna, (2024) argues that the CL model is widely applied in modern education systems, promoting active engagement and collective learning experiences, which are essential to encourage deeper understanding and critical thinking skills among learners.

Table 4. Methodology and Research Results of the CL

Reference	Duration of Treatment	Number of Participants	CTS Instrument	Research Results
Huang et al., (2017)	9 weeks	32	*Critical thinking disposition & critical thinking skills*	The PBCL model improved critical thinking skills, especially in the low initial ability group. Interviews showed positive views on the use of *Google Tools* in supporting collaborative learning.

Reference	Duration of Treatment	Number of Participants	CTS Instrument	Research Results
Warsah et al., (2021)	3 weeks	2 classes	CT skills test	The experimental group showed an increase in critical thinking, analysis, argumentation, and problem-solving skills.
Kurniawan & Indrawati, (2024)	4 weeks	2 classes	Written test	The experimental group showed improved writing skills and higher post-test scores. They also excelled in idea organization, creativity, and argument development.

Source: Authors' elaboration, 2024

Based on Table 4, the treatment duration in these three studies varied from 3 weeks to 9 weeks, with an average of about five weeks. Shorter durations provide a quick snapshot of the effectiveness of the learning model, while longer durations give participants more time to develop the skills taught. The number of participants also varied, with the first study involving 32 participants, while the other two studies involved two classes with smaller numbers of participants. The average number of participants was around 15 per group. Smaller numbers allow for more in-depth monitoring, but more significant numbers provide more representative results.

The CL model improved critical thinking, analysis, argumentation, and problem-solving skills, especially in groups with low initial ability. CL can also be applied to improve writing skills, including idea organization and argument development. Overall, despite variations in duration and number of participants, these three studies show that collaborative learning models have a positive impact on critical skills.

Discovery Learning (DL)

The DL model is less discussed in the analyzed literature; we only found three corresponding articles. It is an educational approach that encourages learners to be actively involved in the learning process through the exploration and discovery of their concepts (Niman et al., 2024). The CL model encourages rational and ethical reasoning, which in turn strengthens learners' analytical and reflective abilities as they explore ideas and find independent solutions (Manurung & Pappachan, 2025).

Table 5. Methodology and Research Results of the DL

Reference	Duration of Treatment	Number of Participants	CTS Instrument	Research Results
Akihary et al., (2023)	12 weeks	20	Essay test	After the application of the YouTube-assisted learning model, there was an increase in cognitive learning outcomes and critical thinking skills.
Mardi et al. (2021)	6 months	10	Essay test	The experimental group (GDL+PBL) showed improvement in critical thinking skills.
Pramusinta et al., (2019)	6 months	144	Essay test (Ennis 1985 indicators)	DL is more effective in improving critical thinking and metacognitive skills than discussion in field-independent cognitive style learners.

Source: Authors' elaboration, 2024

Table 5 explains that the treatment duration ranged from 12 weeks to 6 months, with an average of about four months. Long durations provided more time for participants to develop critical thinking and metacognitive skills, although shorter durations still showed improvement. The number of participants varied from 10 to over 100, with an average of around 58. Studies with fewer participants allow for more personalized monitoring.

The results showed improvements in cognitive learning outcomes and critical thinking skills. Groups using a combination of specific or technology-assisted learning were more successful in developing critical thinking skills than using only one model. In general, despite variations in treatment duration and number of participants, these results consistently show that more structured and interactive DL, whether technology-assisted or active learning-based, can develop learners' critical thinking and metacognitive skills.

Application of Constructivist Learning Models in the Classroom (Answering RQ2)

The implementation of effective learning models plays a key role in optimizing the teaching and learning process. Models such as *Problem-Based Learning* (PBL), *Project-Based Learning* (PjBL), *Inquiry-Based Learning* (IBL), *Collaborative Learning* (CL), and *Discovery Learning* (DL) offer unique approaches to engage learners and facilitate a deeper understanding of the concepts being taught. Each constructivist model has different characteristics and goals, but overall focuses on increasing learners' active engagement and application of knowledge in a real-world context (Renninger, 2024).

In this section, we discuss the application of each learning model in the classroom, highlighting the syntax used and the roles of educators and learners in the process. Analyzing the stages in each model gives us an understanding of how deeper, collaborative, and exploratory learning can be created. It also provides insight into how interactions and responsibilities in learning are distributed, both to educators as facilitators and to learners as active learners.

Problem-Based Learning (PBL)

The PBL syntax of the 11 studies we analyzed is presented in Table 6, illustrating the stages from problem identification to evaluation of results. Each step also reflects the roles of educators and learners, making the PBL process more structured and effective.

Table 6. Syntax, educator, and learner roles in PBL

Reference	Syntax	Educator role	Learner role
Ding, (2016)	Problem definition, Hypothesis generation, independent research, group negotiation, self-reflection	Give direction, support discussion, and provide space for reflection and evaluation during learning.	Problem discussion, hypothesis formulation, independent research, negotiation, presentation of results, self-reflection, and peer evaluation.
Carbogim, et al., (2017)	Group formation, case reading, problem identification, hypothesis formulation, group discussion, presentation	Encourage critical thinking and independent problem-solving with guiding questions.	Group work, case reading, problem identification, hypothesis formulation, self-study, and collaborative discussion to reach a solution.
Kumar, (2017)	Introduction to PBL, problem-solving, Collaborative process, Assessment	Introducing PBL, providing stepwise problems, collaborative guidance, and assessing critical thinking	Collaboratively analyze, solve problems, find independent solutions, and present results according to objectives.

Reference	Syntax	Educator role	Learner role
Saputra et al. (2019)	Formation of the home team, explanation of objectives, case study, problem identification, expert discussion, home team, presentation and evaluation	Explain objectives, provide case studies, guide group formation, and evaluate learners' understanding.	Actively cooperate in groups, identify problems, participate in expert group discussions, and present results in front of the class.
Yusuf et al., (2020)	Group discussion, material exploration, problem analysis, presentation, conclusion	Guiding material exploration, encouraging group discussion, and providing feedback	Actively discuss problems, explore materials with LBK, analyze issues, present results, and conclude.
Saputro et al., (2020)	Problem orientation, group discussion, information search, solution presentation, reflection and evaluation	Present relevant problems, direct discussions, and provide evaluation and feedback.	Actively analyze problems, work together, formulate solutions, seek information, and present and evaluate solutions.
Silviarza et al., (2020)	Orientation and formulating the problem, collecting data, organization and analysis, communication	Provide direction, support, and guidance in the process of identification, analysis, and presentation of spatial problems.	Active in identifying problems, collecting and analyzing data, and delivering analysis results in discussion or presentation.
Amin et al., (2020)	Problem orientation, organization, investigation, solution development and presentation, valuation	Providing real problems, guiding the discovery of solutions, and evaluating results.	Actively identify problems, investigate, develop solutions, and present and evaluate results.
Suryanti & nurhuda, (2021)	Problem identification, group discussion, information search, presentation, evaluation	Provide direction in problem identification and facilitate information seeking and evaluation.	Actively analyze cases, discuss to formulate solutions, find relevant references, and present results.
Hursen, (2021)	Grouping and problem assignment, use of web 2.0 tools, collaborative work, presentation and evaluation	Give assignments, direct the use of web 2.0 tools, and provide feedback	Work collaboratively, solve problems, use web 2.0 tools for discussion and analysis, present solutions
Orhan, (2024)	Problem introduction, discussion, information seeking, collaboration, and solution presentation.	Guide discussions, provide clarification, and support learners in learning.	Actively identify problems, seek information, discuss, formulate, and present solutions.

Source: Author's elaboration, 2024

Based on Table 6, PBL syntax is similar in structure, although each study emphasizes slightly different aspects of the process. In general, PBL syntax includes stages such as problem presentation, group discussion, information seeking, problem analysis, solution development, and presentation of results. In some articles, there is an element of self-reflection and evaluation, which allows learners to reflect on their understanding and evaluate the learning process and outcomes.

The role of educators in PBL focuses more on the function of learning facilitators (Gonzalez-Argote & Castillo-González, 2024). Educators provide general direction and introduce the problem to be solved, support discussion and collaborative processes without providing direct solutions, and provide space for learners to explore and reflect. Educators also play a role in providing constructive feedback and evaluating learning.

Learners in PBL play an active role in various stages, from problem identification to solution presentation (Safitri et al., 2024). Learners work collaboratively in groups, identify and analyze problems, seek information independently by utilizing existing resources, formulate solutions, and present the results of discussions in front of the class. This process encourages the development of learners' critical, analytical, and communication skills.

Project-Based Learning (PjBL)

The syntax of PjBL from various studies that we analyzed from 8 articles is presented in Table 7, illustrating the stages from planning to evaluating project results.

Table 7. Syntax, educator, and learner roles in PjBL

Reference	Syntax	Educator role	Learner role
Sasson et al., (2018)	Forming groups, designing products, collecting data, analyzing, presenting	Guide the project and support collaboration between learners	Work in groups to design, collect data, analyze, and develop a product and presentation
Adekantari, (2020)	Project selection, project execution, project uploading	Provide guidance and feedback to learners during project implementation	Choose a project, field observation, interview, gather information, and upload results/presentation
Sari & Prasetyo, (2021)	Essential questions, project definition, planning, schedule setting, execution, presentation, evaluation	Provide direction, monitor project implementation, and provide feedback on evaluations.	Identifying questions, selecting, planning, and implementing projects, presenting results, and conducting self-evaluation
Cortázar et al., (2021)	Individual assignments, group work, data collection and collaboration, individual evaluation and reflection	Provide scaffolding, monitor the process, evaluate results, and facilitate discussion and collaboration.	Complete individual tasks, collaborate in small groups, upload results, and individual reflection.
Listiqowati & Ruja, (2022)	Pre-class, In-class, setting theme and objectives, planning, project implementation, reporting, presentation	Provide pre-class video materials, facilitate discussions, project guidance, and report and presentation feedback.	Watch the pre-class videos, participate in the discussions, determine the theme, plan, carry out the projects, and present results.
Witarsa & Muhammad, (2023)	Problem identification, problem formulation, data collection, project documentation, result presentation, reflection	Guide learners through each stage of the project, provide direction and feedback, and participate in reflection and evaluation discussions.	Identifying problems, formulating specific issues, gathering information, documenting findings, presentation of project results, and reflection

Reference	Syntax	Educator role	Learner role
Hao, L. et al., (2024)	Pre-class: Study the material independently. In-class: group discussions, online quizzes, project drafting. Post-class: revision and presentation of results.	Provide materials in the pre-class stage, direct discussions and project planning in class, and provide constructive feedback in the post-class stage.	Study the material independently in pre-class, collaborate in groups to plan and complete the project, and revise the project based on the feedback received.
Dias-Oliveira et al., (2024)	Topic exploration, orientation, research, presentation and debate, evaluation and assessment	Provide direction and feedback rather than being the primary conveyor of information.	Be active in discussions, research, debates, and group projects, and do individual reflection.

Source: Authors' elaboration, 2024

Based on Table 7, PjBL syntax was found to follow a similar flow, although there were variations in some studies. Learning begins with the determination of a relevant project, followed by planning, goal setting, and schedule setting. Then, learners work in groups to collect data, analyze, and produce a product. At the end, learners present the project results and conduct evaluation and reflection, both individually and in groups. In essence, PjBL prioritizes collaboration and enhances communication, in-depth information gathering, and reflection on the process and results (Zhang et al., 2023).

Educators in PjBL act as expert practitioners, facilitators, and guides and play a leading role in students' learning process (Chimwayange, 2024). Helping learners work together, monitoring project progress, and facilitating discussion and reflection. In addition, educators also provide materials, ensure the project runs smoothly, and help learners evaluate the results without being the only source of information.

PjBL places learners to be active in every stage of the project, from choosing a topic, planning, and collecting data to presenting results. Working in groups, conducting field research, and reflecting on their work. In addition, learners also learn independently through pre-class materials and revise the project based on feedback received. PjBL focuses on empowering learners to play a more active role in their learning journey through a process of collaboration, research, and skill development (Lalujan & Pranjol, 2024).

Inquiry-Based Learning (IBL)

The syntax or steps of IBL from the various studies we analyzed are presented in the following table, illustrating the stages from orientation, exploration, hypothesis formulation, and experimentation to evaluation of the results of the investigation.

Table 8. Syntax, educator, and learner roles in IBL

Reference	Syntax	Educator role	Learner role
Arsal, (2017)	Orientation and questioning, hypothesis formation, investigation, analysis and interpretation, making conclusions, evaluation	Providing real problems, facilitating the process of observation and hypothesis formation, and guiding the activities of analyzing and evaluating research results.	Asking questions, developing hypotheses, collecting data, analyzing and interpreting findings, drawing conclusions

Reference	Syntax	Educator role	Learner role
Irwanto et al., (2018)	Exploration, Concept Discovery, Application, Self Evaluation	Guide the inquiry process, moderate the discussion, and ensure all group members are active.	Discussing, analyzing data, formulating hypotheses, drawing conclusions, applying concepts, reflection
Wale & Bishaw, (2020)	Topic discovery, information exploration, explanation of findings, elaboration, draft writing, revision, reflection	Facilitate topic selection, guide exploration of information, and provide feedback for revision and reflection.	Select a topic, gather information, analyze findings, write a draft, and make revisions based on feedback.
Adnan et al., (2021)	Problem posing, data collection, experimentation, information processing, analysis and evaluation	Providing questions/problems, guiding the experimental process, data processing, and analysis.	Gathering information, testing hypotheses through experiments, processing data, analyzing investigation results, finding solutions
Dewi, et al., (2021)	Engage, explore, explain, elaborate, evaluate.	Introducing rules, procedures, problems, guiding learners in the process of exploration, elaboration, and evaluation	Formulate questions and seek answers through observation, experimentation, analysis, linking findings with concepts, and evaluation.

Source: Authors' elaboration, 2024

The IBL syntax used by several researchers in Table 8 is generally similar, although there are variations. Learning begins with a problem to arouse learners' curiosity, followed by exploration, data collection, collaboration to discover new concepts, explanation of findings, and revision of understanding. The final stage involves evaluation and conclusion. Some researchers add explicit steps for topic discovery or emphasize concept application and self-evaluation. An important element of IBL is developing learners' expressiveness, improving their ability to share ideas with others, encouraging the search for alternative solutions, and expressing their ideas and opinions (Severini et al., 2024).

The educator acts as a facilitator in IBL by guiding students in the process of problem discovery, data analysis, and evaluation of research results (Huang et al., 2024). They assist in topic selection, direct discussions, provide constructive feedback for improvement, and ensure the exploration and elaboration process runs smoothly. In addition, educators also assess the learning process and outcomes while ensuring engagement in group discussions.

IBL involves learners playing an active role by asking questions, developing hypotheses, collecting data, and analyzing findings using relevant literature. Engage in group discussions to develop creative solutions and reflect on understanding throughout the process. Essentially, IBL requires learners to actively engage in systematic, critical, logical, and analytical thinking to independently explore and solve a variety of problems (Carracedo, 2025).

Collaborative Learning **(CL)**

Based on the analysis of three articles discussing CL, we found various syntaxes and roles involved in the learning process. It reveals the importance of group discussion, collaboration, and reflection as the main elements.

Table 9. Syntax, educator, and learner roles in CL

Reference	Syntax	Educator role	Learner role
Huang et al., (2017)	Problem identification, data collection, data analysis, assignment preparation, presentation and reflection	Facilitate discussions, guide the use of digital tools, provide feedback, and evaluate results.	Discussing problems, collecting and analyzing data, compiling assignments, presenting results, conducting reflections
Warsah et al., (2021)	Group discussion, lecture, reflection, and feedback	Guiding group discussions and giving constructive feedback.	Group discussion, sharing ideas, solving problems, and reflecting on learning
Kurniawan & Indrawati, (2024)	Collaboration, reflection, development, implementation	Ensure active interaction between group members, encouraging deep reflection on the learning process.	Work in groups to discuss, give feedback, assess work, and improve work based on feedback

Source: Authors' elaboration, 2024

CL involves various syntaxes that support active learning and cooperation between learners. The learning process starts with problem identification, followed by data collection and analysis, and the development of tasks that are then presented and reflected upon. Group discussion is a key element in this learning, where learners share ideas and solve problems together (Mudrikah et al., 2024). This syntax was expanded in another study with the addition of collaboration, reflection, development, and implementation, which gives a fuller picture of how groups work together to develop and implement their ideas.

The educator's role in CL is crucial as a facilitator who guides group discussions and the use of digital tools and provides constructive feedback to ensure interactions between group members remain productive. The educator also provides direction and evaluation of the learners' work so that the learning goes well and the objectives are achieved.

Learners have an active role in CL, discussing, sharing ideas, solving problems, and reflecting on learning. They are responsible for collecting data, organizing tasks, and improving their work based on feedback received. In essence, CL creates an autonomous learning atmosphere where learners observe, interact, support each other, and learn from each other (Ghavifekr, 2020).

Discovery Learning (DL)

The DL syntax we found in this analysis is presented in Table 10, which shows the various important stages that reflect the scientific learning process.

Table 10. Syntax, educator, and learner roles in DL

Reference	Syntax	Educator role	Learner role
Akihary et al., (2023)	Stimulation, problem statement, data collection and processing, verification, conclusion drawing	Providing initial questions, directing problem identification, conducting evaluations	Identify problems, collect and process data, present work for verification
Mardi et al. (2021)	Information seeking, problem discovery, information analysis, problem-solving	Guide in finding, analyzing information, and solving problems.	Seeking information, group discussion, completing tasks, and presenting findings.

Reference	Syntax	Educator role	Learner role
Pramusinta et al., (2019)	Stimulation, problem identification, data collection, data processing, verification, generalization	Guides the process of solution-finding and knowledge-building	Actively search for solutions, collect and process data, verify and generalize.

Source: Authors' elaboration, 2024

The learning process in DL involves several important stages, starting from stimulation to arouse curiosity, followed by problem statements that encourage problem identification, data collection and processing, verification to ensure the accuracy of the information, and drawing conclusions based on the findings obtained. This model gives learners the freedom to discover their knowledge independently, with guidance from educators who guide each stage (Ozdem-Yilmaz & Bilican, 2020).

The educator's role in DL focuses on being a facilitator who guides learners throughout their learning. Encourage curiosity by asking initial questions, helping learners identify problems, and facilitating the search for information and solutions. Provide constructive feedback as learners process data, draw conclusions, and verify findings to ensure the accuracy and relevance of the data collected.

Learners have an active role in DL and are responsible for identifying problems, seeking information, collecting and processing data, and drawing conclusions from findings. Learners engage in group discussions, share ideas, and present findings. In DL learning, learners will discover knowledge independently, focus on the learning process, be self-directed, and reflect on their learning outcomes (Inde et al., 2020).

Advantages and Disadvantages of Each Constructivist Learning Model in Developing Critical Thinking (Answering RQ3)

In this section, we will present the results of our analysis of the strengths and weaknesses of constructivist learning models found in the 30 articles we reviewed. This analysis aims to provide a deeper understanding of the potential and challenges of applying constructivist learning models in educational contexts.

Table 11: Advantages and disadvantages of *Problem-Based Learning* (PBL)

Reference	Advantages	Disadvantages
Ding, (2016)	Enhances critical thinking and enables real problem-based collaborative learning	Takes longer and can cause anxiety for learners who are used to being passive
Carbogim, et al., (2017)	Improve critical thinking skills, collaborate, connect theory with practice, and increase confidence through hands-on experience.	Requires trained tutors, more time, and the challenge of meeting different individual learning needs.
Kumar, (2017)	Encourages independent learning and collaboration and provides a realistic context that is relevant to the real world.	Requires long hours and trained instructors to provide minimal guidance without excessive intervention.
Saputra et al. (2019)	It supports active learning and the development of critical thinking skills and provides meaningful experiences through actual case studies.	It requires more time and readiness of educators and students to manage time and understand the procedures of the learning model.
Yusuf et al., (2020)	Increase active participation and critical thinking skills, and create a technology-based collaborative learning environment.	Requires access to adequate technology and training for educators to utilize LBK media to its full potential.

Reference	Advantages	Disadvantages
Saputro et al., (2020)	Develop higher-order thinking skills and increase self-efficacy, contextual relevance, and collaboration.	Requires time, learner readiness, and instructor limitations.
Silviarza et al., (2020)	Enhance critical thinking and teamwork through hands-on experience and contextual problem-solving.	It takes a long time to prepare, and not all learners have enough prior experience.
Amin et al., (2020)	Increase learner activity, problem relevance, collaboration, and cognitive development.	Requires longer duration, external limitations, and complexity.
Suryanti & nurhuda, (2021)	Encourages group discussion and collaboration and focuses on higher-order thinking skills.	Time constraints and confusion over new material.
Hursen, (2021)	Improve critical thinking skills and collaboration, and instill 21st-century skills such as creativity, communication, and technology.	Requires technology infrastructure and longer implementation time than traditional learning.
Orhan, (2024)	Enhance critical thinking, flexibility, and independent collaboration.	Requires adequate infrastructure and can be challenging for learners with limited technology or collaboration experience.

Source: Authors' elaboration, 2024

Based on the analysis results presented in Table 11, PBL offers many profound advantages, especially in developing critical thinking skills and collaboration among learners. Through PBL, learners not only learn theory but are also exposed to real problems that allow them to think analytically and find solutions together. It also encourages active participation and strengthens confidence by applying their knowledge in situations that are more practical and relevant to the real world. PBL also helps develop 21st-century skills such as creativity, communication, and teamwork.

As with other models, PBL also has some challenges, one of which is that the learning time required tends to be longer. The process of discussion, problem-solving, and in-depth analysis sometimes makes time management more complex, and not all material can be covered in one session. PBL requires instructors who can facilitate discussions without too much intervention, as well as learners who are ready to actively participate. In the context of online learning, PBL also faces challenges related to adequate access to technology, which may prevent learners from collaborating effectively.

Table 12: Advantages and disadvantages of *project-based learning* (PjBL)

Reference	Advantages	Disadvantages
Sasson et al., (2018)	Enhance critical thinking and questioning skills, collaboration, and self-directed learning.	Requires educator training, more time, and more resources.
Adekantari, (2020)	Improve critical thinking skills, contextualize, innovate, and provide meaningful learning experiences.	It requires more time and money and relies on technology, which can be a bottleneck if internet access or devices are not adequate.
Sari & Prasetyo, (2021)	Increase motivation and critical thinking, and encourage active learning, collaboration, and authentic experiences relevant to the real world.	Requires careful preparation and time management and may be challenging to implement in large classes as it requires intensive supervision

Reference	Advantages	Disadvantages
Cortázar et al., (2021)	Improve critical thinking skills, teamwork, and collaboration, and strengthen metacognitive processes through social regulation scaffolding.	Limited in generalizability due to specific samples and lack of physical product testing due to pandemic restrictions.
Listiqowati & Ruja, (2022)	Improve critical thinking skills, motivation, participation, and learning independence.	It requires a longer time for discussion and guidance and requires reliance on the internet and digital devices.
Witarsa & Muhammad, (2023)	Enhance critical thinking, integration of theory and practice, active participation, and teamwork and communication skills.	It requires longer preparation time and requires reliance on supporting infrastructure.
Hao, L. et al., (2024)	Provides practice-based learning experiences, supports critical thinking through project analysis, and integrates theory with practice.	It requires more time for educators to prepare, implement, and train, and it is difficult to ensure even understanding of pre-class materials.
Dias-Oliveira et al., (2024)	Improve critical thinking, communication, and teamwork, and integrate theory and practice through authentic projects.	Requires time, more significant resources, group management, and variable results depending on individual motivation.

Source: Authors' elaboration, 2024

Based on Table 12, PjBL provides various advantages, especially in improving critical thinking, communication, and teamwork skills. This model allows learners to integrate theory with practice through collaborative learning relevant to real-world situations. PjBL also encourages active learning, which increases learners' motivation and learning independence. Authentic learning experiences make learners more engaged and able to develop skills that are useful in the world of work.

More extended time allocation for preparation and implementation, as well as more resources required, are disadvantages of PjBL. Technology limitations and inadequate internet access can be barriers, especially in online learning. In addition, PjBL requires careful management to avoid conflicts within the group, as well as challenges in ensuring an even level of active participation across members. Thus, although PjBL provides significant benefits, challenges in implementation and resources should be considered to maximize its effectiveness.

Table 13: Advantages and disadvantages of *Inquiry-Based Learning* (IBL)

Reference	Advantages	Disadvantages
Arsal, (2017)	Provides active learning experiences, builds independent knowledge, and encourages scientific inquiry.	Less effective in improving critical thinking, and students have difficulty following the learning, the need to improve supporting skills.
Irwanto et al., (2018)	Promotes critical thinking, problem-solving, and collaboration, helping learners connect concepts independently	Requires more time and preparation and relies on the active participation of the group and the role of the facilitator.
Wale & Bishaw, (2020)	Enhance critical thinking, collaboration, and understanding of the relationship between theory and the real world.	Requires an extended learning time and is difficult to apply to learners with low learning independence.
Adnan et al., (2021)	Promotes analytical and critical thinking, as well as active learner engagement, which aids understanding of the material through exploration and discussion.	It requires more time and special skills of educators and is less optimal if learners do not have the motivation to learn independently.

Reference	Advantages	Disadvantages
Dewi, et al., (2021)	Encourages critical, independent, creative, and analytical thinking and helps learners with convergent styles develop.	It takes longer, is less effective for assimilation/divergent learning styles, and requires high facilitation skills.

Source: Authors' elaboration, 2024

The advantages of IBL learning that emerge in the findings in Table 13 include improving critical, analytical, and creative thinking skills. It also supports the development of independent knowledge, problem-solving, and collaboration between learners. IBL also encourages exploration and discussion that deepens learners' understanding of the material, connects theory to real-world applications, and helps develop convergent learning styles.

However, IBL takes longer than conventional learning and relies on the active participation and facilitation skills of educators. The effectiveness of IBL learning is influenced by the level of motivation and learning independence of learners. In addition, learners with specific learning styles may face difficulties in optimizing this model. Overall, IBL is effective in promoting independent and critical learning, but its success depends on teacher readiness and learner motivation.

Table 14. Advantages and disadvantages of Collaborative Learning (CL)

Reference	Advantages	Disadvantages
Huang et al., (2017)	Develop critical thinking skills, especially for learners with low initial ability.	Less effective for developing critical thinking disposition (CTD).
Warsah et al., (2021)	Improve critical thinking, social skills, and collaboration.	It takes more time, and not all learners are comfortable with group discussions.
Kurniawan & Indrawati, (2024)	Improving writing, collaboration, critical thinking, and 21st-century skills; communication, creativity, and digital literacy	Takes longer, success depends on active participation, and not all learners are comfortable with group work.

Source: Authors' elaboration, 2024

Table 14. mentions that CL has advantages in developing learners' critical thinking and social skills. This model places learners to be more active in analyzing, evaluating, and solving problems. In addition, CL facilitates important collaboration skills, such as effective communication, tolerance for different views, and the ability to organize ideas in groups. In the context of 21st-century skills, CL also helps learners develop much-needed creativity and digital literacy.

The need for more time is a challenge in implementing the CL model, especially if groups of learners are not able to work well together. The success of CL relies heavily on the active participation of each individual, but some learners may feel uncomfortable with group discussion activities or peer criticism. In addition, while CL helps hone critical thinking skills, there are indications that it is less effective in developing critical thinking dispositions (CTD; attitudes, mental habits, and tendencies to think critically), especially for learners with low initial abilities.

Table 15. Advantages and disadvantages of *Discovery Learning* (DL)

Reference	Advantages	Disadvantages
Akihary et al., (2023)	Enhance critical thinking through active and independent learning and relevant learning experiences.	Requires educator skills in managing technology and reliance on internet connectivity

Reference	Advantages	Disadvantages
Mardi et al.	Increase students' independence and creativity in thinking.	It requires the educator's skill to provide appropriate guidance without being overly directive.
Pramusinta et al., (2019)	Improves critical thinking and metacognitive skills and enables cognitive style learning.	Requires the guidance of skilled educators and can be difficult for learners with field-dependent cognitive styles.

Source: Authors' elaboration, 2024

Based on Table 15, developing critical thinking skills is one of the advantages of DL. Through learning that prioritizes independent exploration, DL encourages learners to find solutions and understand concepts more deeply. This hands-on learning can also improve learners' metacognitive skills, which helps them be more aware and regulate their thinking process. In addition, DL allows learners to learn according to their cognitive style, providing a more personalized and relevant experience.

There are some challenges in implementing the Dl model, which requires educators' skills in providing appropriate guidance without being overly directive so that learners can still explore and learn independently. Without wise guidance, learners can feel confused or overwhelmed. In addition, DL can be more difficult for those with *field-dependent* cognitive styles, as they may struggle to navigate a more open and independent learning process.

4. CONCLUSION

Based on the research findings, the application of five constructivist learning models, namely, Problem-Based Learning (PBL), Project-Based Learning (PjBL), Inquiry-Based Learning (IBL), Cooperative Learning (CL), and Discovery Learning (DL) consistently show a significant contribution in developing students' critical thinking skills. Each model has characteristics that encourage the development of critical thinking skills through active interaction, problem-solving, and intensive collaboration.

1. PBL has been shown to be effective in improving learners' analytical abilities and problem-solving skills. The model allows learners to engage in situations that require in-depth analysis of real-world problems, which in turn improves their ability to make critical decisions based on evidence.
2. PjBL provides invaluable experience for learners in managing complex projects collaboratively. This process requires learners to integrate multiple sources of information, plan steps to completion, and critically evaluate results, all of which contribute to the development of critical thinking skills.
3. IBL emphasizes the importance of learner involvement in the process of asking questions and gathering information. This model is effective in increasing students' curiosity and honing their analytical skills when looking for solutions to the questions posed through the process of experimentation and investigation.
4. CL shows that learning based on collaboration between learners in small groups can encourage discussion and critical reflection. With collaboration, learners are given the opportunity to share ideas, consider different points of view, and develop critical thinking skills in a dynamic social context.
5. DL allows learners to discover knowledge independently through exploration and hands-on experience. It requires learners to process information independently and evaluate their findings more reflectively.

PBL is the most effective model for developing critical thinking. However, PjBL and IBL are also very effective in developing critical thinking; PBL stands out because of the emphasis on real-world problems that challenge learners to think more analytically and reflectively. In addition, group work in

PBL provides an opportunity to enrich each other's ideas and develop critical thinking skills in a more structured manner.

Based on the conclusions, educators are advised to select and implement constructivist learning models that are appropriate to the context and learning objectives. PBL and PjBL models can be applied to situations that require honest and collaborative problem-solving. IBL is very suitable for developing students' curiosity so they are more active in asking questions and finding solutions independently. For classes that focus more on cooperation and discussion, CL can be used to encourage learners to share ideas and think critically together. At the same time, DL is more suitable in situations where learners are given the freedom to explore and discover their knowledge.

Future research could deepen the exploration of how these five constructivist learning models are applied in various classroom contexts and more specific disciplines. It is also necessary to explore the factors that influence their effectiveness in various learning environments. Further research could also include longitudinal studies to see how these learning outcomes are sustained in learners' daily lives.

REFERENCES