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A Systematic Review of Pedagogical Models to Enhance Students' Critical Thinking in Physics Learning

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Abstract: Critical thinking skills are important skills needed in the 21st century Critical thinking skills can be trained in students through student-centered learning This research aims to identify learning models that can improve physics critical thinking skills through a literature review Data collection is based on Scopus and SINTA database sources This type of document comes from magazine articles tagged "critical thinking", "learning models", "physics learning" for the year (2019-2024) Methods adapted from PRISMA were used for the literature search Published documents are based on predetermined content analysis criteria, such as year of publication, author, article source, learning model, physical material topic, research topic, education level, and evaluation Inquiry learning and higher order thinking laboratories (HOT Labs) are the dominant learning models used to improve critical thinking skills The main competency indicators used vary Indicator of critical thinking abilities Self-regulated learning is rarely used in research tools compared to other indicators of critical thinking abilities The instruments used are multiple choice questions, essays, worksheets and observation sheets University-level research participants often use critical thinking skills in their research Fluid mechanics is a popular topic in research This research will help improve students' critical thinking skills through various recommended learning models Research shows that student-centered learning models can improve critical thinking skills.

Keywords: critical thinking skills, fluid mechanics, guided inquiry, learning models, physics learning.

▪ INTRODUCTION

Critical thinking abilities are a fundamental talent required to meet the difficulties of the 21 century, and learning physics is crucial for students to comprehend both physics and the universe (Tiruneh et al., 2017; Duncan, 2020). Scientific research necessitates critical thinking abilities because they allow people to thoroughly study, assess, and construct ideas and arguments. These abilities are crucial for comprehending and addressing abstract and complex physics topics (Furtak & Penuel, 2019).

According to research, critical thinking abilities should be explicitly included in learning objectives (Puig et al., 2019). When students' cognitive talents are affected by goal-directed learning, critical thinking skills can be developed (Thompson, 2011). Learning models and media can help enhance critical thinking abilities (Weatherspoon et al., 2015; Nugraha et al., 2016; Hastuti et al., 2018; Saputri et al., 2019).

Definitions of critical thinking abilities vary among experts. According to Facione (2011), critical thinking abilities enable people to solve issues, comprehend information more fully, and make wiser choices in a variety of life circumstances. Additionally, critical thinking abilities are crucial for professional growth, education, and evidence-

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based decision-making. Facione (2011) states that interpretation, analysis, evaluation, conclusion, and explanation make up the test of critical thinking abilities. According to Binkley et al. (2012), critical thinking abilities are 21st century competencies that support individuals in gaining profound comprehension, resolving challenging issues, and cultivating a variety of thinking techniques required in diverse contexts. According to Binkley et al. (2012), explanation, analysis, interpretation, summary, conclusion, and evaluation are all signs of critical thinking abilities. Ennis (2016) states that Critical thinking skills are invaluable for problem solving, decision making, and deep understanding in a variety of situations.

However, Elder and Paul (2010) demonstrate this The ability to actively examine, formulate, recognize hypotheses, confirm the veracity of evidence, and make decisions based on logical and reasonable assessments are all examples of critical thinking skills. Using scaffolding to teach real-world situations (ŽivkoviL, 2016) and improve students' conceptual comprehension (Sin, 2014) can help students develop critical thinking abilities in physics learning. Asking questions and exercising critical thought are two habits that can help students develop their critical thinking abilities (Hastuti et al., 2018; Ubaidillah et al., 2022). When students are given a problem and attempt to solve it through cooperative and participatory work, knowledge-building processes take place (Malik & Ubaidillah, 2020 and 2021).

In the context of learning physics, critical thinking abilities are obviously relevant. Students' critical thinking abilities are enhanced by studying physics, according to research (Foote & Martino, 2018; Hadi et al., 2018; Seranica et al., 2018). Five primary areas of critical thinking skills training, assessment, instructional tactics, categorization, and the use of technology in education have been identified by prior research evaluations. Assessment, learning tactics, and methods for enhancing engineering students' critical thinking abilities have all been covered in earlier studies (Ahern et al., 2019).

Based on the literature review, learning critical thinking skills is very important in physics education A systematic literature review examines efforts by physics researchers and educators to develop students' critical thinking skills. According to empirical research, Indonesian students' critical thinking abilities are concerning. The average reading, maths, and science scores of Indonesian students in the 2018 Programme for International Student Assessment (PISA) were 371, 379, and 389, respectively. These scores fell short of the OECD standards of 487, 487, and 489. Furthermore, 82% of maths, 75% of reading, and 66% of science results were below Level 2, suggesting poor problem-solving and critical thinking skills . Students' ability to think critically is greatly enhanced by physics education. Students studying physics must be able to analyse, assess, and resolve complicated problems tasks that are fundamental to critical thinking. These abilities are becoming more and more important in the Fourth Industrial Revolution (Industry 4.0) age.(Susanti et al., 2019)

Teachers of physics should be highly competent and cultivate soft skills like communication, creativity, critical thinking, and teamwork. Higher-order thinking abilities that are necessary to meet the problems of the Industry 4.0 era can be developed through effective physics instruction. Thus, there is an urgent need to raise the standard of physics instruction with an emphasis on critical thinking abilities. In order to address the intricacies and dynamics of the Fourth Industrial Revolution, there is a global need for human resources with the capacity for critical and adaptable thinking (Widyawati et al., 2021)

The literature review focuses on learning models that improve students' critical thinking abilities, indicators and assessments of critical thinking abilities, physics material taught, and educational level This literature review is important to provide information to researchers, teachers and educational practitioners about learning models that can improve critical thinking skills in physics learning The results of this literature review provide a strong foundation for planning and developing more effective physics education curricula that encourage strong critical thinking skills.

Table 1. Research question

RQ 1	What learning models are most effective in improving critical thinking skills in physics education?
RQ 2	What physics materials are most effective in improving critical thinking skills in physics education?
RQ 3	What indicators and instruments are commonly used to assess critical thinking in physics?

▪ METHOD

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) technique is used to carry out the steps of identification, screening, feasibility testing, data inclusion, analysis, and presentation in the form of descriptions in order to facilitate the SLR method.(H. Ibda, 2023)

Inclusion and Exclusion Criteria of Publication

At this stage, the researcher determined nine criteria for selecting articles. First, the articles must be indexed by Scopus and SINTA. Second, the review was limited to peer-reviewed scientific articles. Simultaneously, other forms of literature such as theses, dissertations, papers, book chapters, conference proceedings, research reports, and books were excluded. Third, the articles must have been published between 2019 and 2024. Fourth, the articles should focus on ICT education in primary schools. Fifth, the search for articles was conducted exclusively using the Publish or Perish 7 application, which facilitates the retrieval of Scopus- and SINTA-indexed articles explicitly by incorporating an API key into the application. Sixth, only articles from Scopus-indexed open-access journals were utilized, while those from closed-access journals were excluded unless they could be downloaded and indexed on platforms such as ResearchGate.net, Academia.edu, Eric.ed.gov, and Issuu.com. Seventh, only articles available in full PDF format were included, while articles requiring additional steps to obtain the full PDF were excluded.

Screening and Eligibility Assessment for Data Analysis

At this stage, a screening of literature findings from Scopus and SINTA was conducted from January 25 to January 29, 2024. The screening focused on the title, abstract, and keywords. Different keywords were used to refine the search criteria, ensuring the retrieval of a wide range of articles.

Based on the table above, the article search results using keywords related to "critical thinking" and "physics education" in the Scopus and Sinta databases are summarized as follows. The keyword "Pedagogical models for critical thinking" found 85 articles in the Scopus database, while "Critical thinking in physics education" found 78 articles in the same database. In the SINTA database, the keyword "Models to enhance critical thinking in learning" found 70 articles, and "Physics learning with pedagogical approaches" found 65 articles. The highest number of articles, 92, was found in the Scopus database using the keyword "Critical thinking skills in physics learning." Meanwhile, the keyword "Pedagogy for critical thinking in STEM education" found 55 articles in Scopus. In the SINTA database, "Physics education and critical thinking" found 88 articles, and "Innovative models for physics education" found 74 articles in Scopus. Overall, a total of 607 articles were found in both databases, demonstrating significant attention to the topic of critical thinking and its integration into physics education.

Table 2. Article search results are based on Scopus and Sinta databases

No	Keywords	Database	Total
1	Pedagogical models for critical thinking	Scopus	85
2	Critical thinking in physics education	Scopus	78
3	Models to enhance critical thinking in learning	SINTA	70
4	Physics learning with pedagogical approaches	SINTA	65
5	Critical thinking skills in physics learning	Scopus	92
6	Pedagogy for critical thinking in STEM education	Scopus	55
7	Physics education and critical thinking	SINTA	88
8	Innovative models for physics education	Scopus	74
	Total		**607**

The findings from the search yielded 812 articles, but not all were selected and reviewed; duplicate articles were removed. In the final stage, 61 articles were selected, imported into the Mendeley application, and saved in RIS format.

PRISMA Flow Diagram

The article search process using the PRISMA flowchart follows four structured schemes: identification, screening, eligibility, and inclusion. These four schemes were implemented to obtain articles relevant to the research theme. During the identification stage, 607 articles indexed in Scopus and SINTA were found with the help of the Publish or Perish 7 application, as shown in Table 2. In the screening stage, the articles were checked for similarity based on keywords, resulting in 489 articles being found, from which 118 articles were selected. The determination of similarity does not refer to the database itself, as this SLR method uses only Scopus and SINTA databases. Thus, the similarity was reviewed based on the keywords used. From the screening stage, 92 articles were selected, while 26 irrelevant articles were excluded. In the eligibility stage, 44 articles were selected for full-text reading, while 48 articles were discarded. At the inclusion stage, 37 articles were selected based on research questions concerning the title, abstract, keywords, and content of the articles. The final step involved importing all selected articles in RIS format into Mendeley for analysis, mapping, and presenting the results in alignment with the research questions.

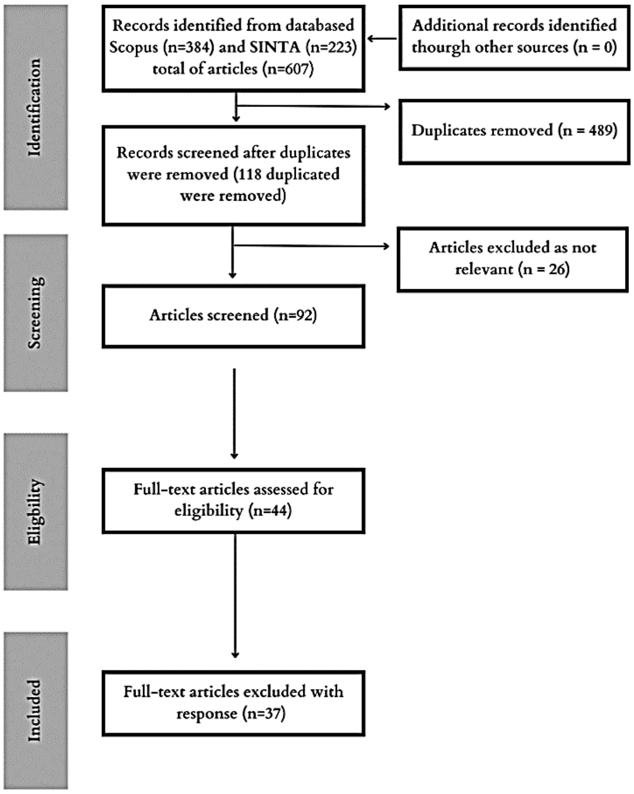

Figure 1. Prisma flow diagram for systematic literature review

▪ RESULT AND DISSCUSSION

Data analysis was carried out based on learning model criteria, indicators of critical thinking skills and type of equipment, level of education used as research setting, and physics material topics. The article data is organized into four categories regarding learning models that improve critical thinking skills, types of indicators and instruments for critical thinking skills, the level of education where the research was conducted, and physics subject matter

Learning Models are Most Effective in Improving Critical Thinking Skills in Physics Education

The learning model includes practical and academic activities Critical thinking skills are strengthened through laboratory activities that incorporate discussion into problem solving The hands-on science learning approach allows students to participate through direct experience doing, experimenting, observing, and touching natural objects and laboratory equipment Practical studies are based on practical experience and concrete investigations Mind on Science currently focuses on conceptual understanding and critical thinking Students more often think, reflect, and consider scientific concepts through discussion, analysis, and problem solving The learning model used to improve critical thinking skills is presented in Table 3.

Learning models to improve critical thinking skills (Table 3) are classified into seven categories This classification is based on consideration of the technological characteristics necessary to enhance students' learning experiences, learning context, and problem-solving, results-oriented, and critical thinking skills. Critical thinking skills The classification of learning models is shown in Table 3 The results of a literature review from various studies Guided inquiry, Project Based Learning, Problem Based Learning, Discovery Learning, STEM education, Discussion learning, Ethno science-based direct instruction, Reflective-inquiry learning (RIL), Review, Overview, Presentation, Exercise, Summary (ROPES), Focus Explore Reflect Apply (FERA), Socio-scientific issues, Clarity Learning Model, Flipped Classroom, Cooperative Learning, Clarity Learning Model (CLM), Disaster-Based Learning, Inquiry-based learning. The classification of learning models show that guided inquiry are the learning models most commonly used to improve students' critical thinking skills.

Guided Inquiry have become dominant pedagogical models in physics education due to their effectiveness in enhancing students' critical thinking skills. For instance, a demonstrated that implementing a guided inquiry learning model significantly improved high school students' critical thinking abilities in physics (J. K. Putri et al., 2024; Wibiane & Imam, 2020; Yulia Amanati & Muslimin Ibrahim, 2019). In contrast, models like Reflective Inquiry Learning are less frequently employed in physics education. A study by (Verawati et al., 2021) inindicated that while the reflective-inquiry learning model could improve preservice teachers' critical thinking abilities, its application in physics education remains limited. To enhnce its effectiveness, integrating reflective inquiry with hands-on experimental activities and leveraging digital tools for reflection could be beneficial. Further research is needed to explore its potential in physics education contexts.

The utilization of unstructured case studies encourages students to do independent research and resource exploration skills that are important in the nursing field and might be the first step toward tenacity. Instead of lecturing, the teacher's function in PBL is that of a facilitator. By providing scaffolding, guiding inquiry, reiterating comprehension of challenging topics, and presenting resources, the facilitator aids the groups in creating understanding and making connections between ideas. The facilitator also encourages group members to reflect on the process and results of the group. In addition, the facilitator could be thought of as a mentor or coach who offers advice and support(Sujanem & Putu Suwindra, 2023). PBL enhanced the analysis and interpretation components of critical thinking in her recent study on the impact of PBL on nursing students' critical thinking(Iqbal & Doris, 2023). Investigated how PBL affected the development of higher order cognition in nursing students. Their findings were consistent with earlier research showing that PBL was a more efficient way to get students involved in application, analysis, assessment, and synthesis than standard lectures (Mohammad et al., 2021; Putranta et al., 2019)

The research background included in the review being developed comes from countries such as the Indonesia, Irak research was conducted by (Hasanan Abbas Sahib ALsabari, 2021) and (Mahmoud Abdel Hakim Saleh, 2024), Turkey was conducted by (Pelin ÜNLÜ, 2023), Pakistan research was conducted by (Iqbal & Doris, 2023), Kenya was conducted by (Basweti et al., 2019), Vietnam was conduct by (Huynh et al., 2022), Emirates was conduct by (Mohammad et al., 2021).The results of review were dominated by research from Indonesia.

Table 3. Learning models that can improve critical thinking skills

No	Author	Model of Teaching	Frequency	Article Category
1	(Danika Pranata et al., 2023; Latifah et al., 2021; Mat et al., 2023; Pelin ÜNLÜ, 2023b; Perdana & Rosana, 2019; J. K. Putri et al., 2024; Setiawan et al., 2019; Wibiane & Imam, 2020; Yulia Amanati & Muslimin Ibrahim, 2019)	Guided inquiry	9	National
2	(Fadilah et al., 2023; Hikmah et al., 2023; Khoiri et al., 2023; Mahzum, 2020; R. K. Putri et al., 2021; Rapi et al., 2022)	Project Based Learning	6	National
3	(Dul Aji et al., 2023; Pratiwi & Hariyono, 2022; Putranta et al., 2019; Sujanem & Putu Suwindra, 2023)	Problem Based Learning	4	National
4	(Fariyani & Miskiyah, 2022)	Discovery Learning	1	National
5	(Indahwati et al., 2023; Parno et al., 2019)	STEM education	2	National
6	(Sunarti et al., 2023; Zainudin & Pambudi, 2019)	Discussion learning	2	National
7	(Risdianto et al., 2020)	Ethno science-based direct instruction	1	National
9	(Verawati et al., 2021)	Reflective-inquiry learning (RIL)	1	National
10	(Karlina Muzianti & Sofi Makiyah, 2023)	Review, Overview, Presentation, Exercise, Summary (ROPES)	1	National
11	(Nurhalimah & Rizal, 2024)	Focus Explore Reflect Apply (FERA)	1	National
12	(Febriani et al., 2023)	Socio-scientific issues	1	National
		Clarity Learning Model	1	National
8	(Dwi Sulisworo et al., 2019; Mohammad et al., 2021)	Flipped Classroom	2	International
13	(Mahmoud Abdel Hakim Saleh, 2024)	Cooperative Learning	1	International
14	(Huynh et al., 2022)	Clarity Learning Model (CLM)	1	International
15	(Basweti et al., 2019; Iqbal & Doris, 2023)	Problem Based Learning	2	International
16	(Hasanan Abbas Sahib ALsabari, 2021)	Disaster-Based Learning	1	International
17	(Pelin ÜNLÜ, 2023)	Inquiry-based learning	1	International

The table 3 provides an analysis of various teaching models used to improve students' critical thinking skills, incorporating findings from several authors. Guided Inquiry is the most frequently used teaching model, cited in nine articles. Researchers such as Danika Pranata et al. (2023), Latifah et al. (2021), Mat et al. (2023), Pelin ÜNLÜ (2023b), Perdana & Rosana (2019), J. K. Putri et al. (2024), Setiawan et al. (2019), Wibiana et al. (2020), and Yulia Amanati & Muslimin Ibrahim (2019) highlight its effectiveness. This model facilitates structured exploration and investigation, helping students develop critical thinking by encouraging them to actively engage in the learning process.

Project-Based Learning emerges as another widely adopted model, with six articles, including studies by Fadilah et al. (2023), Hikmah et al. (2023), Khoiri et al. (2023), Mahzun (2020), R. K. Putri et al. (2021), and Rapi et al. (2022). This approach allows students to engage in real-world projects that require collaboration, planning, and problem-solving, making it highly relevant to fostering critical thinking. Additionally, Problem-Based Learning, reported in four articles, is explored by Dul Aji et al. (2023), Pratiwi & Hariyono (2022), Putranta et al. (2019), and Sujarsem & Putu Suwindra (2023). This model enables students to solve authentic problems, enhancing their analytical and evaluative skills in the process.

Other teaching models also contribute to critical thinking improvement, although their usage is less frequent. For instance, Discovery Learning is highlighted in one article by Fariyani & Miskiyah (2022), focusing on students' independent exploration to uncover new concepts. STEM Education, as noted in two articles by Indahwati et al. (2023) and Parno et al. (2019), integrates science, technology, engineering, and mathematics, promoting interdisciplinary problem-solving abilities. Discussion Learning, emphasized by Sunarti et al. (2023) and Zainudin & Pambudi (2019), fosters critical argumentation and idea evaluation in group settings.

Some unique models also appear in the table, such as Ethno-Science-Based Direct Instruction (Risdation et al., 2020) and Reflective-Inquiry Learning (RIL) (Verawati et al., 2021b), which each appear in one article. While these approaches are less commonly used, they showcase diverse methods to support students' critical thinking. Furthermore, the Review, Overview, Presentation, Exercise, Summary (ROPES) model, explored by Karlina Muziranti & Sofi Makiyah (2023), and the Focus, Explore, Reflect, Apply (FERA) model, as described by Nurhalimah & Rizal (2024), provide innovative frameworks for learning that encourage critical analysis and reflection. Similarly, the Socio-Scientific Issues model (Febriani et al., 2023) connects learning with real-world scientific debates to sharpen students' critical perspectives.

At the international level, Flipped Classroom, examined by Dwi Sulisworo et al. (2019) and Mohammad et al. (2021), has gained recognition. This method enables students to study materials independently before class, allowing for in-class discussions and problem-solving activities. Cooperative Learning, discussed by Mahmoud Abdel Hakim Saleh (2024), and Clarity Learning Model (CLM), introduced by Huynh et al. (2022), emphasize collaboration and structured clarity in learning. Additionally, Disaster-Based Learning, as explored by Hasanan Abbas Sahib Al-Sahari (2021), integrates real-world disaster scenarios to enhance critical thinking skills. Finally, Inquiry-Based Learning, addressed by Pelin ÜNLÜ (2023), emphasizes active student engagement in asking questions, conducting investigations, and drawing conclusions.

In conclusion, the table reveals that Guided Inquiry, Project-Based Learning, and Problem-Based Learning dominate as the most frequently used models to enhance critical thinking. However, other innovative approaches, including STEM Education, Flipped Classroom, and reflective learning models like RIL and FERA, also play a significant role in fostering students' critical thinking skills, as shown through the contributions of various national and international researchers.

The teaching methodology emphasizes both hands-on and mind-on science activities. Critical thinking skills are enhanced through laboratory activities that incorporate discussion in problem solving. Students who are taught using hands-on scientific methods benefit from having the opportunity to practice making, analyzing, and bending natural objects or laboratory apparatuses The practical knowledge is centered on practical experience and experiential exploration. Conversely, mind-on-science places more emphasis on conceptual understanding and critical thinking. More students are questioning, challenging, and strengthening concepts often via discussion, analysis, and problem-solving. The teaching model used to increase students' critical thinking skills is shown in Table. The learning model that can increase critical thinking.

This classification is based on the characteristics of student learning, the learning environment, problem solving, results orientation, and technology that is useful in enhancing critical thinking skills. Research conducted in Belgium by Sermeus (2021) employs a form of inquisitive inquiry that is conducive to increasing critical thinking skills. Results of the review conducted by Mutakinati dkk. (2018), Suryani dkk. (2018), Verawati dkk. (2021), Wahyudi dkk. (2019b), Malik dan Ubaidillah (2020), and Lestari dkk. (2021) are the most prominent among Indonesian studies.

Guided Inquiry has become the dominant teaching model for enhancing critical thinking because it directly engages students in higher-order cognitive processes such as analysis, evaluation, and synthesis. This model allows students to actively explore and investigate while receiving structured guidance from teachers, fostering a balance between independence and support. Its student-centered nature encourages active participation, enabling learners to construct their knowledge rather than passively absorbing information. Furthermore, Guided Inquiry promotes metacognition, as students are required to plan, monitor, and reflect on their thought processes, which strengthens their ability to think critically. Collaborative aspects of this model also play a significant role, as discussions and problem-solving activities expose students to diverse perspectives, encouraging deeper analysis and more thoughtful reasoning. Research, such as that by (Danika Pranata et al., 2023) and (Pelin ÜNLÜ, 2023b) has consistently demonstrated its effectiveness, showing that students in Guided Inquiry settings develop stronger critical thinking skills compared to those in traditional classrooms. This combination of active learning, metacognition, and collaborative engagement makes Guided Inquiry a powerful and scientifically validated approach for fostering critical thinking.

The findings of this Systematic Literature Review (SLR) could potentially be generalized to global issues related to work readiness assessment; however, the representativeness of the articles depends on the scope and diversity of the studies included. From the table, it is evident that the majority of articles cited are from national sources, with only a few originating from international studies. For instance, articles like those by Mahmoud Abdel Hakim Saleh (2024), Huynh et al. (2022), and Hasanan Abbas

Sahib Al-Sahari (2021) reflect broader perspectives as they contribute insights from international contexts. These studies enhance the global applicability of the findings, particularly in highlighting diverse educational models like Cooperative Learning, Clarity Learning Model, and Disaster-Based Learning.

However, the predominance of national articles, such as those by Danika Pranata et al. (2023) and Indahwati et al. (2023), indicates that the findings are heavily rooted in localized contexts, which might limit their universal applicability. For the findings to be claimed as globally representative, they should draw from a more balanced pool of international and national research. A broader geographic and cultural representation, such as studies encompassing various continents or education systems, would further support the generalization claim. That said, the inclusion of internationally recognized models like STEM Education (Parno et al., 2019) and Flipped Classroom (Dwi Sulisworo et al., 2019; Mohammad et al., 2021) indicates an alignment with global trends in education, lending partial credibility to the generalization. These models are widely discussed in international discourse and reflect universal principles of critical thinking and work readiness. In conclusion, while the findings offer valuable insights, the limited representation of international studies in the dataset calls for caution in fully generalizing the results to a global context. A more diverse set of articles would strengthen the validity of such claims.

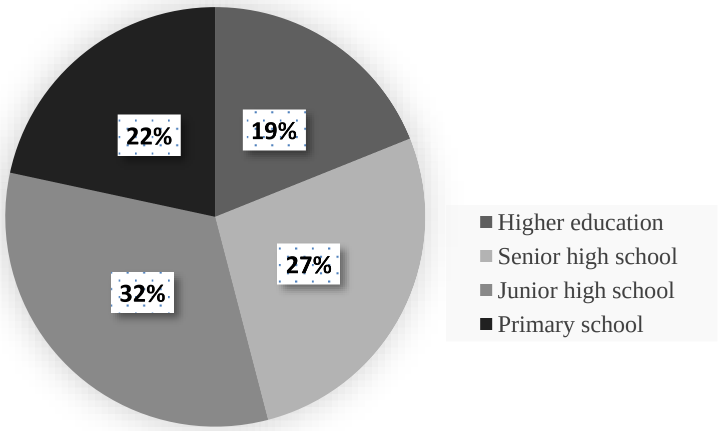

Figure 2. Classification based on level of education frequency

The pie chart titled "Classification Based on Level of Education Frequency" illustrates the distribution of educational attainment levels within the analyzed dataset. The largest proportion is represented by individuals with a Junior High School education, accounting for 32% of the total. This indicates that the majority of individuals have attained education up to the junior high school level as their highest qualification. Following this, the Senior High School category constitutes 27%, suggesting that a considerable portion of the population has completed secondary education, although it remains lower than the junior high school group. The Primary School category makes up 22% of the distribution, reflecting a notable share of individuals whose educational attainment is limited to primary school. Conversely, the group with Higher Education represents the smallest percentage, at only 19%, highlighting that a relatively small fraction of individuals have progressed to tertiary education. Overall, the data reveal that the majority of individuals fall within the middle levels of education, particularly junior and senior high school, while participation in higher education is comparatively low. This pattern may point to challenges in access to or opportunities for pursuing advanced education. Addressing these gaps could be critical for promoting equitable access to education and increasing the proportion of individuals reaching higher educational levels.

The Physics Materials are Most Effective for Improving Critical Thinking Skills

There is a wide range of outcomes from mapping articles about physics topics taught to enhance critical thinking abilities. Every subject matter has distinct qualities that can foster pupils' critical thinking. The most researched topic when it comes to developing critical thinking abilities is fluid mechanics. The least utilized materials are elasticity, sound and waves, optics, light, measurements, states of matter, physics scientific words, photoelectric effect, electricity and magnetism, and electric current. The table displays the categorization according to the topic matter of physics.

Table 4. Classification of physics material

N	Physics Material	Frequency
1	Fluid mechanics	7
2	Static fluid	4
3	Electricity	4
4	Work and energy	3
5	Temperature and heat	3
6	Force and laws of motion	2
7	Mechanics	2
8	Magnetic field	2
9	Elasticity	1
10	Sound and wave	1
11	Optics	1
12	Light	1
13	Measurement	1
14	Substance form	1
15	Physics scientific terms	1
16	Photoelectric effect	1
17	Electricity and magnetism	1
18	Electric current and elasticity	1

The Indicators and Instruments are Commonly Used to Assess Critical Thinking

The findings of the article review indicate that there is a wide range in the authors' references to critical thinking abilities in their work. In the publications under study, Binkley's capacity for critical thought is most frequently utilized as an indication. Eight papers contain six measures of Binkley's critical thinking abilities. Similar to Ennis' critical thinking skills, Facione's critical thinking abilities are present in a large number of articles, although their signs differ greatly amongst them. Table 5 displays the outcomes of the paper assessment based on indications of critical thinking ability.

Table 5. Indicator of critical thinking indicators used in research

No	References	Indicator of Critical Thingking	Frequency
1	Binkley et al., 2012	Explain, analyze, interpreting, synthesizing, inference and evaluation	8
2	Facione, 1990	Analysis, inference, evaluation and decision-making	6
3	Facione, 1990	Interpretation, analysis, evaluation, inference, explanation and self-regulation	5
4	Facione, 1990	Interpretation, evaluate arguments, inference and Explanation	2
5	Facione, 2011	Interpretation, analysis, evaluation, inference and explanation	1
6	Ennis, 1985	Providing simple explanations, building basic skills, making conclusions, making further explanations, and arranging strategies and tactics	4
7	Ennis, 2016	Basic clarification, the bases for a decision and inference skills	1
8	Ennis, 2016	Basic clarification, the bases for a decision and inference skills	1
9	Ennis, 1995	The skills to formulate the problem, give the argument, induction, evaluating and to decide a course of action	1
10	Ennis, Millman, & Tomko, 2005	Deduction, induction, assumption, observation and credibility	1
11	Ennis 2011; Facione, 2011; Lai 2011	Focus on the question, analyze arguments, decide action, observing induces data, further explanation	1
12	Paul-Elder, 2010	Critical thinking based on purpose and question, selection of information, assumption, point of view the solution, implication and consequences	1
13	Dressel & Mayhew, 1954	Ability to clarify the problem situation, gather information, accept the agreement, set up the hypothesis and reasonably conclude	1
14	Etkina & Planinšič, 2015	Asking question and defining problem, analyzing, interpreting data, prediction, explanation, evaluation assumption	1
15	Halpern, 2010	Hypothesis testing, verbal reasoning, argument analysis, likelihood and uncertainty analysis, problem-solving and decision-making	1

▪ CONCLUSION

Information about initiatives to strengthen students' critical thinking abilities in physics classes across several nations has been made available by this review. This study reveals how practitioners employ learning models, tools for critical thinking, educational levels, and physics resources to enhance critical thinking abilities. Using learning that includes students in problem-solving through laboratories, presenting questions that provoke cognitive conflict, real-world challenges, investigations, and projects may all help students' critical thinking abilities when learning physics.

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