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The Impact of Flipped Learning on Students` Critical Thinking; A Systematic Literature Review

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Abstract. Flipped learning is a revolutionary teaching method that disrupts traditional learning environments by providing instruction outside of the classroom. This strategy enables students to engage with the subject at their convenience and encourages active learning in the classroom. The current study is a comprehensive literature analysis that looks into the impact of flipped learning on student critical thinking skills. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) criteria were utilized to ensure that the article selection was valid and reliable. The articles were selected from some credible databases, such as Eric, Scopus, and ProQuest. After the selection procedure, the systematic review yielded 23 relevant articles to

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be further reported. Our analysis highlights that flipped learning practices are most commonly observed in natural science disciplines, including physics, mathematics, and chemistry. The majority of the studies employed quantitative methodologies, primarily utilizing quasi-experimental designs, and predominantly focused on university-level students in Asian countries. Notably, the findings indicate a substantial positive effect of online-based flipped learning on the enhancement of students' critical thinking skills, suggesting that this pedagogical approach can significantly benefit student learning outcomes.

Keywords: Flipped Learning; Critical Thinking Skill; Systematic Literature Review; Pedagogical Strategy; Teaching Method

1. Introduction

Critical thinking is described as an intentional self-regulatory judgment that drives problem resolution and decision-making (Dwyer, 2023). This concept is important for the students since it allows them to think sensibly, make the right decisions, and select the best options for themselves (Amalia et al., 2019). It will also help students tackle future issues since it encourages them to think broadly and thoroughly about numerous topics (Hidayani et al., 2020). Other than that, critical thinking skills enable students to move beyond theoretical knowledge and apply taught concepts to real-world circumstances, fostering the ability to solve challenges using both academic learning and practical experience, which is very important in the acquisition of knowledge (Papageorgiou, 2023). In this case, educators agree on the value of critical thinking disposition and its impact on student learning outcomes, emphasizing the need to develop critical thinking abilities to enhance educational experiences (Palavan, 2020). Therefore, critical thinking is identified as a 21st-century ability that is becoming increasingly important in modern education, with a focus on preparing students` to be productive and employable in the workforce (Rumch, 2023). Theories suggest that explicit training in critical thinking abilities is essential for their development, and educators are encouraged to incorporate these skills into their teaching techniques across all courses (Butler, 2024). This integration is more than just a pedagogical preference; it is essential for preparing students for the complexities of current life and work contexts (HAO, 2023).

When it comes to the importance of critical thinking for students`, empowering them with critical thinking is essential. In this scenario, selecting the suitable learning technique that fosters the growth of students' critical thinking is essential. In this case, one learning method that is stated to be effective in empowering students` critical thinking is flipped learning. Flipped learning has been found to have a favorable link with students' critical thinking skills in a variety of educational settings. It is because flipped learning provides the prerequisite activities needed to enhance students` critical thinking, which could encourage active learning, engagement, and higher-order thinking skills (Suprapti et al., 2021). In this case, the flipped classroom approach allows students to engage with course content before class, enabling them to actively apply their knowledge during in-class activities, conversations, and problem-

solving assignments that are favorable to developing critical thinking abilities (Tomesko et al., 2022). Yerizon et al. (2022) stated that flipped learning encourages pupils to think critically, examine data, and make informed selections, leading to a deeper level of comprehension and skill development. Therefore, the flipped classroom is stated to be effective in improving students' cognitive skills, problem-solving abilities, and self-efficacy, all such are essential components of students` critical thinking (Wijayanto et al., 2023; Handrianto et al., 2023).

Several scholars conducted empirical studies on the influence of flipped learning on students' critical thinking using both quantitative and qualitative methods. For example, Ekaputra (2023) found that the flipped classroom project-based learning paradigm had a substantial impact on students' logical reasoning capacity and learning activity (correlation coefficient = 0.813). Novalinda et al. (2023) reported the improvement in critical analysis, collaboration, communication, and creativity skills amid students through the Content-Based Instruction Flipped Learning Integrated with Problem-Based Learning based on Collaborative Flipped approach. Tomesko et al. (2022) also reported a similar result, where A virtual flipped classroom style improved critical thinking in online graduate classes, by promoting active learning and student engagement. In the aspect of qualitative procedure, Setiyawan et al. (2024) demonstrated that flipped classroom approaches resulted in considerable improvements in critical mathematical thinking and self-regulated learning among Science, Technology, Engineering, and Mathematics students. Other than that, Yulian (2021) demonstrated that the flipped classroom paradigm improved logical reasoning and evaluative reading among students in post-secondary education who speak English as a foreign language. Wandi (2023) also reported that the flipped classroom improved student involvement and critical thinking skills.

Numbers of empirical studies can be found in the literature, but research based on a literature review gathered theoretical information on the effect of flipped learning on student critical thinking is scarce. For example, a study carried out by Nugraheni et al. (2022). However, the literature review did not use a systematic procedure such as PRISMA, where the article selection procedure only explored the keywords in the database and considered 16 articles. Other flipped learning research based on literature review was conducted in higher education (Baig and Yadegaridehkordi, 2023; Purwaningtyas et al. 2020), and in mathematic area (Fernández-Martín et al. 2020). The current literature lacks complete information about the use of flipped learning to empower students' critical thinking skills through specific techniques, such as a systematic literature review.

It is vital to do a systematic literature review research on the integration of flipped learning and student critical thinking. First, a systematic literature review enables researchers to discover and assess all relevant research on the issue related to the topic, resulting in a thorough grasp of the available data. Second, a systematic review can help researchers find patterns, trends, and gaps in the literature. Researchers can get insights into the efficiency of flipped

learning in improving students' critical thinking skills across various educational contexts and disciplines by combining findings from many studies. This comprehensive study can help discover topics for additional investigation and lead future studies in this discipline. Therefore, the current research with the systematic literature review procedure aims to reveal and provide information about the impact of flipped learning on students` critical thinking in several aspects:

1 In what country the research was carried out?
2 In what school level was it implemented?
3 Is flipped learning impacting students critical thinking?
4 What context was used?
5 What is the flipped-based learning approach used?
6 What research approach was used?

2. Research method

The current study is a systematic literature review (SLR) designed to address a specific research question. SLR is known for its thorough evaluation of current knowledge, detecting trends, knowledge gaps, and areas that require more inquiry (Ren et al., 2019). In this case, a systematic literature review provides a methodical approach to analyzing and exploring recent literature (Hidayat & Wardat, 2023). Through a systematic literature review, the goal of the current research was to investigate how flipped learning could be used to help students improve critical thinking skills. Through this thorough analysis, the study hopes to shed light on the potential results of using flipped learning to help students build critical thinking abilities.

A thorough literature review has several purposes, including validating current practices, reconciling discrepancies, identifying emerging trends, suggesting future research directions, investigating conflicting findings, and making recommendations to improve decision-making (Antons et al., 2021). The SLR technique thoroughly assesses the existing information, allowing for specific analysis of the gap addressed in the current study. Several database were utilised in this research namely Scopus, ProQuest, and ERIC. These databases were chosen because of their specific advantages. Scopus provides extensive journal coverage and is widely used for bibliographic analysis (Singh et al., 2021); ProQuest provides a comprehensive collection of full-text journals across various disciplines; and ERIC is known as the world's most extensively published educational research article database (Adhikari et al., 2020). Keywords were constructed to find suitable journal articles based on research topic-related terms and phrases. Here are the keywords: TITLE-ABS-KEY (“Flipped-classroom" OR "Flipped-learning") AND (“Critical-thinking” OR “Critical-thinking-skill”).

Table 1. Keywords

Keywords	The structure and configuration of the keywords
Flipped classroom Critical thinking	TITLE-ABS-KEY ((“Flipped-classroom" OR "Flipped-learning") AND (“Critical-thinking” OR “Critical-thinking-skill”))

Abelha et al. (2020) argue that systematic literature review research frequently lacks rigor in technique. In this context, PRISMA functions as a methodological norm, giving a checklist of criteria to assure the empirical validity of data. In the current research, PRISMA used to make sure the validity and reliability of the result. Page et al. (2021) define PRISMA as a methodological technique that improves transparency and accuracy while decreasing the chance of errors in systematic reviews. PRISMA consists of four critical stages: identification, screening, eligibility, and inclusion. Figure 1 shows a PRISMA-based flow chart summarizing these stages.

Identification

Scopus, ProQuest, and the ERIC database were used to search for relevant publications. The keywords provided in Table 1 namely "flipped classroom" or "flipped learning" and "critical thinking” or “critical thinking skills." were filled into the database. In this case, the search just limited itself to the keyword given. Furthermore, the search was limited to full-text publications, articles authored in English, and those published between 2018 and 2024. To ensure relevancy, search engines were set to target phrases found in the paper titles and abstracts. The search yielded 3,297 articles, including 1,400 from Scopus, 1,521 from ERIC, and 376 from ProQuest. After evaluating the total of 3,297 articles retrieved from multiple databases, we discovered and deleted duplicate entries, resulting in a final count of 3,293 definite articles included in this systematic literature review.

Screening

The following phase entailed screening to detect and delete duplicate items. Four duplicates were discovered and eliminated from the 3,297 articles collected during the identification stages using the PRISMA approach (Fig. 1). The remaining articles were evaluated, and those that did not fit the specific criteria stated in Table 2 for the article title, publication year, document type, language, and accessibility will be excluded. Article names must specifically relate to flipped-based learning and students' critical thinking skills; any that veer from this topic were removed. The articles chosen were published between 2018 and 2024 to ensure their timeliness and relevance. In terms of document type, only original research published in scientific publications was evaluated. The articles were also required to be written in English, which is the worldwide language of scholarly communication, enabling the inclusion of articles from many geographical regions. Furthermore, only full-text, open-access articles were included to streamline the analysis procedure. As a result, 3.250 articles were deleted during the screening stage based on provided criteria.

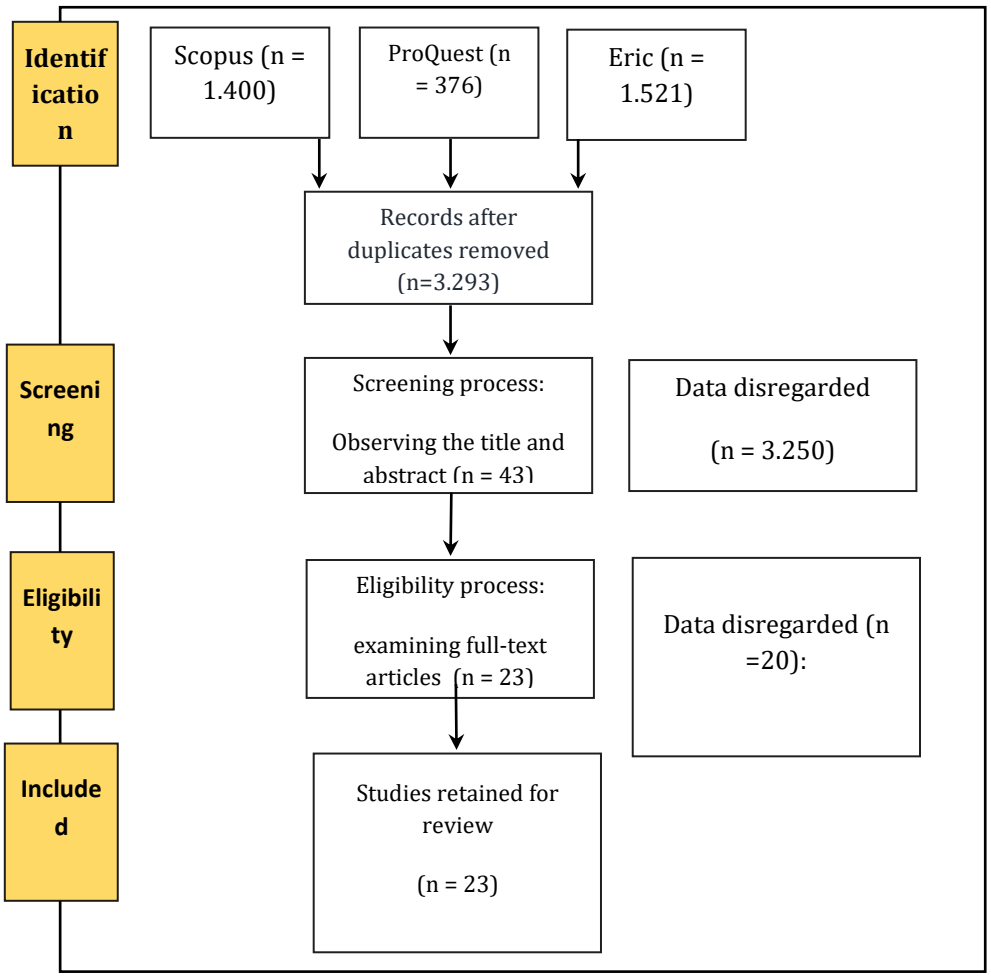

Figure 1. PRISMA flow chart for the research selection procedure

Eligibility

After the screening phase, 43 articles progressed to the eligibility stage. During this stage, researchers conducted a thorough review of each article to ensure compliance with the established requirements. This assessment included an in-depth inspection of the full text, and articles were eliminated if they did not focus. The current research focuses on several factors such as learning context, research approach, school level, and the country of study. The researchers established criteria for picking acceptable articles, which included topic-related titles, papers describing the influence of flipped-based learning on students' critical thinking skills, and relevance to preset keywords.

However, many articles did not meet these established criteria and were excluded due to unrelated titles, discussions of topics outside the selected keywords. As a result, 20 articles were removed from the analysis. Although these articles addressed critical thinking, some were excluded because they focused on critical thinking as a teaching method rather than as a skill developed in students. Furthermore, articles that did not explicitly relate the impact of the

flipped learning to students' critical thinking, such as those centered on participants' perceptions of flipped learning implementation or literature reviews discussing only the practice of flipped learning, were also excluded.

Inclusion

The review procedure determined the validity and reliability of the selected papers. In this scenario, researchers strictly adhere to the guidelines outlined in the PRISMA protocol to improve the validity and reliability of the articles while minimizing the chance of bias. The reporting phase includes 23 papers, as specified by PRISMA protocol procedures.

Table 2. Outline of the criteria used for inclusion and exclusion

Aspect	Inclusion	Exclusion
Title and content of the article.	A suitable title that meet the criteria.	irrelevant and failed to meet the standards.
Publication year	Publication in between 2018 to 2024	Other than the specified range
Type of publication	Original research and journals.	Excluding studies that are non-empirical, along with reviews and editorials.
Language	English	Others
Subject focus of the article	Flipped based learning and critical thinking skill	Aside from Flipped based learning and critical thinking skill
Accessibility	Full-text articles	Preview and fee are required
Critical thinking	As the skill objected	As the teaching method etc

Data analysis

In this comprehensive literature study, researchers uncover various factors that may influence the implementation of flipped learning and its influence on students' critical thinking abilities. These variables include the research method (qualitative versus quantitative), educational environment, grade level, and geographic location. To investigate these aspects, we looked at how the study methods used influenced the findings published in the literature. For example, quantitative studies frequently produce measurable outcomes regarding students' critical thinking improvements, whereas qualitative studies may provide insights into students' experiences and perceptions, highlighting various aspects of critical thinking development.

By categorizing the research systematically based on these variables, we hoped to identify patterns and draw conclusions about how each feature contributes to the success of flipped learning in improving students' critical thinking skills. Each element was evaluated to discover its specific impact on implementation, with a focus on how variations in the study approach may lead to different conclusions about the success of flipped learning. Prior to data analysis, thematic analysis identified, analyzed, and interpreted patterns or themes in qualitative data. (Clarke and Braun, 2017). The data under consideration consisted of articles acquired using the PRISMA methodology, which is described in the methodology section. Following the PRISMA approach, 22 publications were identified for analysis, resulting in a review of 23 articles to be reported in the findings.

3. Result

In the current systematic literature review, several aspects of the implementation were considered, including the learning context, the research approach used, the school level, the flipped-based learning approach, the effect of flipped-based learning on student analytical reasoning abilities, and the country where the study took place.

Learning context

The researchers examined the various contexts in which flipped learning was implemented to enhance students' critical thinking skills. The findings revealed a range of learning contexts, with the most prevalent being the natural sciences. Specifically, 11 articles addressed flipped learning within this domain: two in general science (Atwa et al., 2022; Hwang et al., 2022), three in physics (Rahayu et al., 2022; Rapi et al., 2022; Widodo, 2022), two in mathematics (Chimmalee and Anupan, 2023), and two in chemistry (Aidoo et al., 2022; Andrini et al., 2019). Additional articles focused on other subjects within the natural sciences, including one in the context of the sun, earth, and moon (Öz and Kala, 2023) and one in biology (Simatupang et al., 2023).Following the natural sciences, the language context was represented by five articles, with four pertaining to English language learning (Etemadfar et al., 2020; Atwa et al., 2022; Yulian, 2021; Chen and Hwang, 2019) and one focusing on a foreign language (Orhan, 2023).
The business context included two articles: one in accounting (Ibrahim et al., 2018) and another in business education (Hao et al., 2024). Additionally, flipped learning was explored in geography (two articles, Astawa et al., 2022; Listiqowati et al., 2022), public speaking (one article, Irianti et al., 2024), information technology (one article, Atwa et al., 2022), history (one article, Fadli et al., 2022), debate (one article, Liu and Sukavatee, 2019), nursing materials (one article, Chang et al., 2020), and engineering (one article, Dutta et al., 2023).

Research Method

In terms of research method, almost all the current implementation of flipped learning on student critical thinking was found to be implemented in the quantitative procedure with a quasi-experiment design with a total of 22 articles (Aidoo et al. 2022; Andrini et al. 2019; Astawa et al., 2022; Atwa et al., 2022; Chang et al., 2020; Chen and Hwang, 2019; Chimmalee and Anupan 2023; Dutta

et al., 2023; Etemadfar et al., 2020; Fadli et al., 2022; Hao et al. 2024; Hwang et al. 2022; Irianti et al., 2024; Listiqowati et al., 2022; Liu and Sukavatee 2019; Orhan 2023; Öz and Kala 2023; Rahayu et al., 2022; Rapi et al., 2022; Simatupang et al. 2023; Widodo 2022; Yulian 2021) and only one article used the qualitative procedure (Ibrahim et al. 2018).

In the school level the flipped learning on students critical thinking was applied

The third research question was concerned with the school level. The result indicated that among the 23 articles analyzed, one article did not mention the school level at which the research was carried out. It was found that the majority of the flipped learning on students` critical thinking was commonly done at the university level (n = 14; Aidoo et al. 2022; Andrini et al. 2019; Chang et al. 2020; Chen and Hwang 2019; Chimmalee and Anupan 2023; Dutta et al. 2023; Hao et al. 2024; Ibrahim et al. 2018; Irianti et al. 2024; Listiqowati et al. 2022; Orhan 2023; Rahayu et al. 2022; Widodo 2022; Yulian 2021), followed by high school (n = 5) (Fadli et al. 2022; Astawa et al. 2022; Simatupang et al. 2023; Liu and Sukavatee 2019), junior high school (n = 1) (Atwa et al. 2022), private institution (n = 1) (Etemadfar et al. 2020), and elementary school (n = 1) (Hwang et al. (2022). Based on the result, it was found that flipped learning on students` critical thinking was commonly implemented at the university level.

Learning Approach

The fourth research question was concerned with the learning approach used in the flipped learning on students` critical thinking. This research question examined how flipped learning was modified and used in the context of students` critical thinking. Based on the findings, it was discovered that some articles did not modify or add other learning approaches to the implementation of flipped learning on students critical thinking (n = 7) (Etemadfar et al. (2020); Irianti et al. (2024); Atwa et al. (2022); Dutta et al. (2023); Yulian (2021); Simatupang et al. (2023). However, there are several articles that report modified flipped learning. For example, online-based flipped learning (n = 3), which modified as online-flipped-based learning (Widodo 2022), online-flipped-based learning combined with Kahoot and plicker applications (Orhan 2023), and online Edpuzzle platform-flipped learning (Öz & Kala 2023) Other than that, project-based flipped learning was used in two research projects: project-based flipped classroom (PjBFC) (Listiqowati et al., 2022) and flipped learning combined with project-based learning (Andrini et al., 2019). Other research reported modified flipped learning as creative problem solving (Rahayu et al. 2022), emergency map visualization (Astawa et al. 2022), project performance review (Rapi et al. 2022), concept mapping (Chen & Hwang 2019), RSI (recognize, summarize, inquire) (Chang et al. 2020), cloud-based learning (Aidoo et al. 2022), hybrid learning (Hao et al. 2024), and debate instruction (Liu and Sukavatee 2019). Based on the findings, it was known that the most modified models of flipped learning were online flipped learning and project-based flipped learning.

The Impact of Flipped Learning on Students' Critical Thinking

The fifth research question was concerned with the effect of flipped learning on students` critical thinking skills. Based on the findings, since most of the articles in the current research were in the form of quantitative quasi-experimental design, it can be stated that the impact of flipped learning on students` critical thinking was significant. For example, there is a substantial difference between the controlled and experimental groups of students using flipped learning in the english language classroom and the foreign language classroom. (Atwa et al. 2022; Chen and Hwang 2019; Etemadfar et al. 2020; Orhan 2023; Yulian 2021). There were also found the significant impact in the context of natural science material such as articles in general science (Atwa et al. 2022; Hwang et al. 2022), physics (Rahayu et al. 2022; Rapi et al. 2022; Widodo 2022), mathematics (Chimmalee and Anupan 2023), chemistry (Aidoo et al. 2022; Andrini et al. 2019), sun earth and moon material (Öz and Kala 2023), and biology education (Simatupang et al. 2023). It was also reported in the context of business (Hao et al., 2024), geography (Astawa et al., 2022; Listiqowati et al., 2022), public speaking (Irianti et al., 2024), IT (Atwa et al., 2022), history (Fadli et al., 2022), debate (Liu and Sukavatee, 2019), nursing (Chang et al., 2020), and engineering education (Dutta et al., 2023). In the context of qualitative research, it was found that using flipped learning has helped students improve their communication and critical thinking skills. (Ibrahim et al. 2018). As a result, both quantitative and qualitative research indicates that flipped learning has a considerable impact on students' critical thinking skills.

The country where the study takes place

The sixth research question was concerned with the country where the study took place. It is important to know in which country students most utilize the flipped learning for critical thinking skills. Based on the result, it was found that that the majority of the study was conducted in Asia, such as in Iran (n = 1) (Etemadfar et al. 2020), Indonesia (n = 9) (Irianti et al. 2024; Fadli et al. 2022; Rahayu et al. 2022; Astawa et al. 2022; Yulian 2021; Listiqowati et al. 2022; Widodo 2022; Simatupang et al. 2023; Andrini et al. 2019), Taiwan (n = 2) (Chang et al. 2020; Hwang et al. 2022), Thailand (n = 3) (Chimmalee and Anupan 2023; Liu and Sukavatee 2019), China (Hao et al. 2024), and Palestine Atwa et al. (2022). Another study was found in Africa, specifically in Ghana (Aidoo et al. 2022), and Europe, specifically in Turkey (n = 2) (Orhan 2023; Öz and Kala 2023).

Table 3. article analysis result

No	Authors	Context	Research method	School level	Learning approach	The impact	Country
1	Etemadfar et al. (2020)	English listening	Quantitative (quasi experiment)	Private institution (intermediate level)	Flipped based learning facilitated with internet, computer and projector	The results revealed significant variations in English listening comprehension and critical thinking skills between the two groups, with the experimental group performing better.	Iran
2	Irianti et al. (2024)	Public speaking	Quantitative (quasi experiment)	University level	Flipped learning	A notable relationship was identified between the flipped classroom approach and students' public speaking performance, especially when taking into account their critical thinking abilities.	Indonesia
3	Atwa et al. (2022)	Science, math, IT and English	Quantitative (quasi experiment)	Primary school level (SMP)	Flipped learning	The experimental group demonstrated enhanced critical thinking skills, higher Math achievement, and less psychological stress.	Palestine
4	Fadli et al. (2022)	History	Quantitative (quasi experiment)	High school students (SMA)	Flipped learning	The results showed that the flipped classroom approach to history education had a	Indonesia

						considerable influence on increasing pupils' critical thinking abilities.	
5	Dutta et al. (2023)	The Karnaugh map (K-Map). Engineering	Quantitative (quasi experiment)	University students	Flipped learning	Using augmented reality (AR) technology improves participants` critical thinking skills.	Not mentioned
6	Rahayu et al. (2022)	Physics	Quantitative (quasi experiment)	University students	Creative problem solving flipped learning	The t-test analysis results reveal that the flipped classroom approach is more effective than the control group using creative problem solving (CPS). The CPS-flipped classroom outperformed the traditional CPS method, demonstrating the flipped classroom's potential as an alternative method for online learning.	Indonesia
7	Astawa et al. (2022)	Geography	Quantitative (quasi experiment)	High school	flipped classroom learning based on disaster maps	The study found a significant effect, both concurrently and partially, with a significance level of <0.05.	Indonesia

					visualization.		
8	Yulian (2021)	English language	Quantitative (quasi experiment)	University students	Flipped learning	The study found that the flipped classroom teaching paradigm increased students' critical thinking.	Indonesia
9	Listiqowati et al. (2022)	Geography	Quantitative (quasi experiment)	University students	Project-Based Flipped Classroom (PjBFC)	The findings showed that the Project-Based Flipped Classroom (PjBFC) model, which uses both synchronous and asynchronous tactics in online learning, had a significant impact on increasing pupils' critical thinking abilities.	Indonesia
10	Rapi et al. (2022)	physics	Quantitative (quasi experiment)	Not mentioned	Flipped classroom based project assessment	The flipped classroom-based project assessment fosters analytical reasoning abilities and conceptual knowledge.	Not mentioned
11	Chen and Hwang (2019)	English	Quantitative (quasi experiment)	University students	Concept mapping based flipped learning	The posttest results demonstrated that idea mapping had a favorable and significant impact on English as a Foreign Language (EFL) learners'.	Not mentioned

12	Chang et al. (2020)	Nurse material	Quantitative (quasi experiment)	University students	RSI (recognize, summary, inquire) based flipped learning	The study revealed that the RSI-based flipped classroom method boosted students' learning critical thinking.	Taiwan
13	Chimmalee and Anupan (2023)	Mathematic	Quantitative (quasi experiment)	University students	Flipped cloud based learning	To summarize, using mathematical thinking enhancement tactics within flipped cloud learning improves students' mathematical critical thinking skills.	Thailand
14	Aidoo et al. (2022)	chemistry	Quantitative (quasi experiment)	University students	Flipped inquiry based learning	The quantitative data analysis revealed a considerable improvement in students' academic performance and critical thinking skills.	Ghana
15	Widodo (2022)	Physics	quantitative study with one group pretest-postest research design	University students	Online (Google Classroom Learning Management System) flipped based learning	The results indicated that the online-flipped classroom effectively facilitated the development of students' critical thinking skills, achieving an average normalized change of 0.71, which falls into the high	Indonesia

						category.	
16	Orhan (2023)	Foreign language	Quantitative (quasi experiment)	University students	Online (Google Classroom Learning Management System) flipped based learning combined with Kahoot and plicker application	Online, flipped, and in-class explicit critical thinking instruction significantly improved university students' critical thinking skills and dispositions, yielding a large effect size. Additionally, the flipped classroom emerged as the most effective learning environment for promoting critical thinking skills and dispositions, followed by online and in-class settings.	Turkey
17	Öz and Kala (2023)	Sun, earth, moon	Quantitative (quasi experiment)	Secondary school students	Online (Edpuzzle platform) flipped learning	The flipped classroom approach led to a considerable boost in academic success and critical-analytic thinking.	Turkey
18	Simatupang et al. (2023)	(Biology) human respiratory system	Quantitative (quasi experiment)	High school (SMA)	Flipped learning	The flipped classroom learning paradigm helps students` of SMAN 16 Medan enhance their critical thinking skills.	Indonesia
19	Hao et al. (2024)	Business	Quantitative (quasi	University students	Hybrid project based learning	The results indicated that both project-based learning and	China

			experiment)			flipped classrooms had a significant impact on enhancing students' critical thinking and creativity.	
20	Ibrahim et al. (2018)	accounting	Qualitative	University students		The study's results demonstrated that the implementation of the flipped learning effectively enhanced students' communication and critical thinking skills.	Malaysia
21	Hwang et al. (2022)	Natural science	Quantitative (quasi experiment).	Elementary school		The experimental group demonstrated considerable improvements in critical thinking abilities.	Taiwan
22	Andrini et al. (2019)	Chemistry	Quantitative (quasi experiment).	University students	Flipped learning combined with project-based learning	The Flipped Classroom and Project-Based Learning Model increases students' analytical reasoning abilities, with a significance level of less than 0.05.	Indonesia
23	Liu and Sukavatee (2019)	Debate	Quantitative (quasi experiment)	High school	Debate instruction based flipped learning	The findings revealed that debate-based flipped learning had a positive impact on critical thinking skills, as	Thailand

						evidenced by the quantitative data from the opinion questionnaire. Additionally, qualitative data from focus group interviews indicated students' overall satisfaction and favorable approval of this approach.	

4. Discussion

In the current study, six variables were considered: the context, the research approach, the school level, the learning approach, the effect of flipped learning on students' critical thinking skills, and the country where the study was conducted. In terms of the context, this research revealed that the flipped learning on student critical thinking used in various learning context, but the most common one was in the natural material such as general science, physics, mathematic, chemistry and biology. The implementation of flipped learning on students critical thinking in the natural science material might be caused by the critical thinking itself is essential to be used in natural science subject such as biology and physics. As stated by Noris et al., (2024) natural science such as math, physics and biology require students to engage in higher cognitive processes, such as analysis, synthesis, assessment, conclusion, and critical thinking. Fuadiyah et al. (2022) also stated that critical thinking is a fundamental aspect in the subject since it requires students to construct concept, synthesising idea, analysing data and evaluating information.. Wenno et al. (2022) stated that learning implemented in biology and physics education has been found to boost students' critical thinking skills. It was emphasised by Ristanto et al. (2020), who found that the students` analytical reasoning abilities was enhanced through the study of biology education.

The current research also analyzed the research approach used in the implementation of flipped learning on students` critical thinking skills. It was found that among the 23 articles analyzed, 22 used quantitative procedures, namely quasi-experimental research design, and only one article used qualitative procedures. Quasi-experimental research is a research approach that predicts outcomes obtained through actual experiments (De Vocht et al., 2021). This design enables researchers to study the impact of interventions by comparing the outcomes of an experimental group that receives the treatment to those of a control group that does not (Muslimin & Amran, 2019; Uslan et al., 2024). This research approach is essential to use since it could reveal valuable insight about the effectiveness of interventions, treatments, or educational strategies (Arifin et al., 2020; Qudratuddarsi et al., 2022). For example, the research in the effectiveness of debate instruction-based flipped learning, flipped learning combined with project-based learning, or flipped cloud-based learning on student analytical reasoning abilities (Andrini et al., 2019; Chimmalee and Anupan, 2023; Liu and Sukavatee, 2019). However, this reliance on quantitative methods has limits. Because of the paucity of qualitative investigations, the study is limited in its capacity to capture students' personal experiences, attitudes, and the broader context of the learning environment. Qualitative research might have provided more nuanced insights into how flipped learning promotes the development of critical thinking, delivering a fuller knowledge beyond numerical results.

Aside from that, the current research found that the practice of flipped learning to increase students' critical thinking was widely used throughout Asia, mainly in Indonesia, Malaysia, and China. It might be caused by the Asian countries emphasise on educational achievement and rigor. In many Asian countries,

education is highly valued, with a significant emphasis on academic accomplishment, particularly in topics such as mathematics, science and technology (Boman, 2022). This cultural emphasis may support the use of flipped learning in natural sciences such as physics, mathematics, and chemistry, where students are expected to excel in standardized testing and competitive academic settings. This desire for achievement is likely to make new teaching methods such as flipped learning appealing for improving critical thinking, which is essential for excelling in these disciplines. Other than that, the current research confirms that flipped learning on students critical thinking is commonly done at the university level. It's understandable since university teachers frequently expect students to think critically by solving problems and conducting projects (Van Der Zanden et al., 2020). It is because the higher the level of education, the higher the cognitive skills required. Tikhomirova et al. (2020) stated that higher education levels are related to higher cognitive functioning, memory, and reasoning skills. In this case, critical thinking is known to be a key skill for academic achievement and professional enhancement from the start of university studies (Hyytinen et al., 2018). Tosuncuoğlu (2018) emphasizes the importance of students' critical thinking views and ability to govern their thinking processes for academic success. It is also said that university students who have critical thinking skills demonstrate greater improvement in these skills during their studies (Zanden et al., 2020). Therefore, cultivating critical thinking in university students through various learning approaches, including the flipped learning method, is an essential practice at the university level.

Researchers found that the implementation of flipped learning on student critical thinking was modified and added to other learning approaches and concepts. For example, the flipped inquiry-based learning or debate-based learning. The most typical flipped-based learning approach used in the enhancement of students` critical thinking was online flipped learning and project-based flipped learning. Online flipped learning is an educational strategy in which students interact with course contents before class using pre-recorded videos or online resources, allowing them to access learning resources freely and at their own pace (Ahmad & Arifin, 2021). This strategy contradicts the typical learning model, in which students are taught knowledge in class and then practice or review it outside of class (Agarwal et al., 2021). The online component of flipped learning usually includes accessing materials via a learning management system (LMS) and completing online quizzes or exercises (Ahmad & Arifin, 2021). The use of online flipped learning might be caused by the current escalation trend in the use of online learning. Nasution (2022) explains that the COVID-19 pandemic has considerably accelerated the spike in online learning, encouraging educational institutions globally to increasingly utilize online learning to ensure educational continuity and provide flexible learning possibilities for students. This transformation has resulted in a significant growth in the creation and adoption of online learning platforms and materials, including flipped learning (Dhawan, 2020).

The current research found that, based on quantitative and qualitative research, flipped learning has a major impact on students' critical thinking skills. The reason why flipped learning could influence student critical thinking is because this learning method promotes student self-learning and interaction with the learning material. Zain and Sailin (2020) stated that flipped learning focuses on constructing students` knowledge themselves, developing a feeling of responsibility for their own learning. It makes students interact more with the learning material in the form of videos, texts, or projects outside of class, allowing for more interactive and engaging classroom activities during in-person sessions (Ortin, 2023). Furthermore, the flipped classroom paradigm has been shown to boost learner engagement and foster a sense of ownership over one's education (Oh et al., 2022). By actively engaging with learning material and self-learning, students have the chance to construct their own thinking process and generate their own thinking skills.

5. Conclusion

The current study is a comprehensive literature analysis that looks into the impact of flipped learning on student critical thinking skills. The study concluded that the adoption of flipped learning on student critical thinking is more common in natural sciences such as physics, mathematics, and chemistry. The majority of recent studies on this topic used quantitative methodologies and a quasi-experimental research design. Aside from that, university students in Asian countries frequently used flipped learning to enhance their critical thinking skills. In this example, the most prevalent flipped learning strategy was online-based flipped learning, with the majority of articles claiming that it had a significant impact on student critical thinking skills.

The limitation of this systematic literature review includes its emphasis on natural sciences (physics, mathematics, and chemistry), which limits its applicability to other fields such as social sciences or humanities. Most research was done in Asian countries, notably among university students, limiting the findings' application to other locations and educational levels, such as elementary or secondary education. Furthermore, the study relied significantly on quantitative, quasi-experimental designs with little qualitative insights, and it mostly used online-based flipped learning models, which may be impractical in resource-constrained environments. The research was also rather short-term, leaving the long-term impacts of flipped learning on critical thinking untested. Future research should expand to other subjects, regions, and educational levels, employ mixed-method approaches, investigate non-technological flipped learning models, and conduct longitudinal studies to gain a more comprehensive understanding of the impact of flipped learning on students' critical thinking skills.

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