



Review of Relevant Literature About Critical Thinking Skills in a Science Perspective

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Abstract: Critical Thinking (CR) is one of the most important thinking skills and is a widely recognized measure of the quality of student learning. The literature reviewed shows the importance of integrating critical thinking (CR) into curriculum content and teaching methods in a tiered manner. This study uses the Systematic Literature Review (SLR) method, to map where CT is taught, which countries have research trends on CT, how to teach and assess CT, and the influence of technology on CT. Documents were analyzed comprehensively in the Scopus database for the 2018-2023 period. There are five stages of SLR research, namely determining keywords, searching for data, selecting documents, validating data, and analyzing data. Only documents in the form of articles published in the journals used were analyzed. The results of the study indicate that critical thinking skills must be taught and trained at the school level, both in elementary schools, secondary schools, and in certain courses. CT teaching is carried out by choosing the right model or strategy, for example using a modified inquiry model or STEM approach strategy. Assessment is carried out using instruments such as critical thinking skills tests or observation rubrics that have been standardized or modified to obtain accurate results.

Keywords: Critical thinking skills; Science perspective; Technology to encourage.

Introduction

In the 21st century, the demand for students to have "4C" competencies, namely: critical thinking and problem solving, creativity and innovation, communication and collaboration to compete in a global society (Hasanah et al., 2023; Ma et al., 2023; Pursitasari et al., 2020). Some of the important changes and trends in education during the 21st century include: educational technology: the use of technology in education has become increasingly common; student-centered approaches to learning: a shift from teacher-centered to more student-centered approaches to teaching; emphasis on skills such as creativity, problem solving, collaboration, critical thinking, and digital

literacy are becoming increasingly important in the workplace; increased attention is being paid to inclusive education, which accommodates the needs of students with diverse abilities and needs; globalization and educational mobility have brought about greater educational mobility; emphasis on lifelong learning; adoption of relevant curriculum: education today emphasizes the importance of a curriculum that is relevant to the real world. Curriculum is designed to teach students about the social, environmental, and economic issues facing society today and prepare them to play a role in addressing these challenges. Thus, education reflects the changes and challenges associated with technological developments, job market needs, and an increasingly connected global perspective and aims

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to prepare students to succeed in an ever-evolving world that provides equal opportunity for all individuals (Rapi et al., 2022).

One of the life skills that needs to be developed in the education process in this century is critical thinking skills. Thinking cannot be separated from human activities, because thinking is a characteristic that distinguishes humans from other living creatures. Fostering the development of students' critical thinking (CT) is regarded as an essential outcome of higher education (Tiruneh et al., 2018). This has changed the way we think and influenced the development of critical, creative and analytical thinking skills.

In the era of information and technology, the speed and amount of information changes day by day and current information is not enough to keep up with the times. Therefore, the need for individuals who follow developments in science and technology closely and can adapt to these changes quickly is increasing day by day (Hebebcı & Usta, 2022). In the education system this is aimed at educating individuals who can construct knowledge by passing through their own cognitive filters rather than just memorizing existing knowledge. Individuals are expected to have a higher order in terms of thinking skills such as self-regulation strategies, critical thinking, problem solving and metacognitive thinking, and so on. Among these skills, critical thinking is a key skill used in most thinking processes (Bilgiler et al., 2019). Eliciting students' critical thinking skills and science process skills as part of transferable skills is a key goal in higher education (Irwanto, 2023; Kleemola et al., 2022; Putra et al., 2023), and it is important for employment and success in the field of work (Kleemola et al., 2022), as well as as one of the most important skills in the twenty-first century (Plummer et al., 2022).

Critical thinking has been conceptualized in many ways (Ennis, 1991; Facione, 1990; Halpern, 1998) but leading theorists generally agree that critical thinking consists of skills in both cognitive and affective domains. Critical thinkers are able to search for, understand, and evaluate relevant statements logically and rationally during the problem solving or decision making process. They also have a tendency or mindset to engage in exploratory and reflective thinking activities (Shaw et al., 2020). Training students' critical thinking can equip them with the skills needed to face the challenges and demands of the 21st century (Hussein et al., 2019) and is one of the main challenges facing higher education in the 21st century (Dekker, 2020).

Learning is defined as the efforts made by teachers to help students carry out educational activities. Implementation is the core of providing education through learning plans made by teachers, which are realized through effective and efficient activities in

accordance with lesson characteristics (Maknun, 2020). Critical thinking is an ambiguous concept that is defined differently by researchers and school theorists. Learning critical thinking skills is a complex process which, among other things, is an important aspect shaped by the teacher's and students' understanding of critical thinking. This study provides a systematic review of the literature on teaching CT skills focusing on articles published in academic journals over the past five years (2018 to 2023). The remainder of the article is structured as follows: First, the methods used to identify and select studies for inclusion in this review are described. The article then presents the conceptual framework of the research and discusses the literature in light of four major debates among researchers in the field of CT teaching. To limit this research, several research questions were asked, namely: where should CT skills be taught; which countries have research trends on critical thinking; how are CT skills taught and assessed; and can technology improve students' CT skills?

Method

This research uses the Systematic Literature Review (SLR) method which aims to identify trends and growth of knowledge in the topic of critical thinking skills in science. In SLR, the Systematic Mapping Study (SMS) method is the initial stage in implementing SLR. The SMS method is more descriptive, further supported by the SLR method which is exploratory and exploitative, thus providing adequate transparency and replication as a research method (Armitage & Keeble-Allen, 2008; Tranfield et al., 2003). In this method, the process of identifying, reviewing, evaluating, and interpreting all available research is carried out. The SLR method is a research design to systematically synthesize evidence based on previous or existing research to answer questions. This Systematic Literature Review is based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method. Stages in conducting this literature review: defining eligibility criteria; define information sources; literature selection; data collection; and data selection.

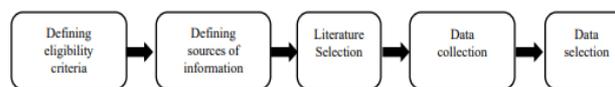


Figure 1. Stages of Literature Review

Defining Eligibility Criteria: Article searches were carried out in March 2023 with the keyword "critical thinking skills". Articles must be research written in English. Define Information Sources: A literature search

was carried out on the Scopus database. Selection of literature: The selection of literature begins by determining the keyword "critical thinking skills" from the 2018-2023 time period. Next, explore the title, abstract and keywords in the articles obtained. Then read in full or partially the articles that have not been eliminated to determine whether they are worthy or not. Data collection: Data collection was carried out manually by creating a data extraction table containing: Article title, year, background, method, results/arguments, conclusions, keywords and selected citations. Data Selection: Selection of related data is related to critical thinking skills. The steps taken in this research can be seen in Figure 2.

variations and contexts. It is used to conceptualize distinctions and organize ideas.

Where should critical thinking skills be taught?

Critical thinking skills must be taught at the school level, whether in elementary school, secondary school, or in certain courses. From the SLR data collected, the mapping of these studies can be seen. For more clarity, you can see the data mapping in Table 1.

Table 1. Mapping of Critical Thinking Skills at the Formal Level

| Level | Quantity of Articles |
|------------------------------------|----------------------|
| Elementary School | 5 |
| Junior High School | 7 |
| High School/Vocational High School | 11 |
| College | 23 |
| Course | 3 |
| Teacher | 1 |
| Total | 50 Article |

If this data is made into a histogram, it will look like in Figure 3.

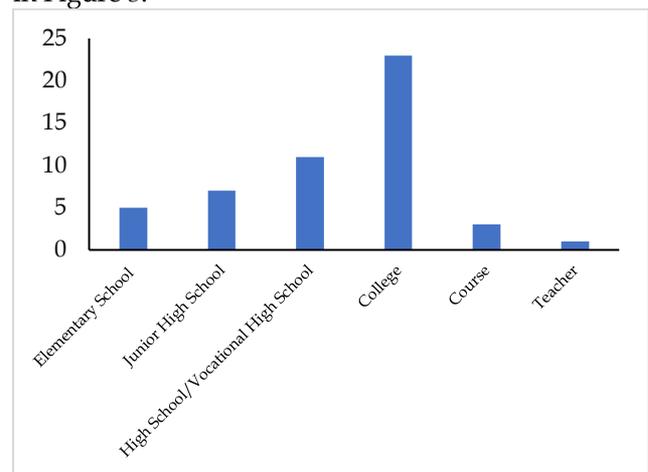


Figure 3. Histogram of Critical Thinking Skills at the Formal Level

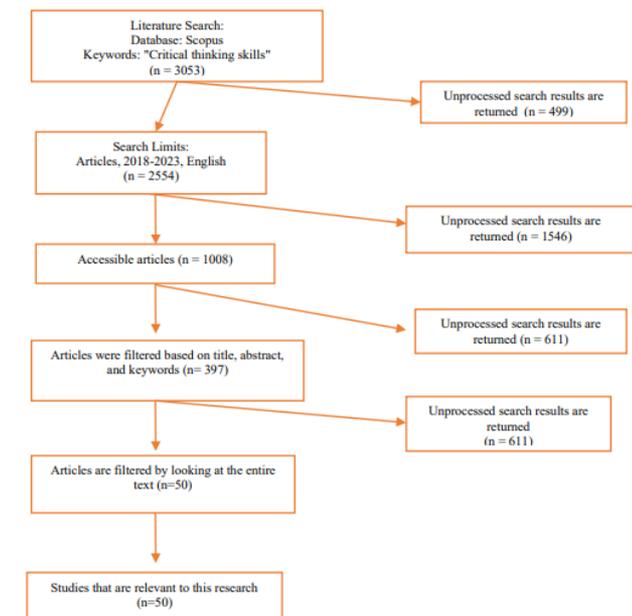


Figure 2. Steps in Carrying out SLR

From the figure 2 it can be seen that articles were searched using Scopus from several academic fields to identify articles related to critical thinking skills. From the data obtained from 2554 articles, 50 articles were selected which were deemed to be in accordance with this SLR. A variety of search terms were used including different variations and combinations of the following terms: 'critical thinking skills', 'teaching critical thinking', 'higher order thinking skills', and 'innovative ways to teach critical thinking skills'.

Result and Discussion

To organize ideas and achieve research objectives, a conceptual framework including four questions about Critical Thinking was used. According to Alsaleh (2020), a conceptual framework is an analytical tool with several

From the mapping, it can be seen that the dominance of studies at the Higher Education (HE) level reflects that the main focus of research is on advanced academic environments. This could indicate that innovation, evaluation, or application of new technologies and methods are widely carried out or tested at the university level. The lack of studies that directly target teachers is an important gap, considering that teachers are the main agents in implementing curriculum and educational innovation. Research is more often conducted on students than educators, so approaches that focus on teacher experience and needs are still lacking, in addition, research at the course or non-formal level is still neglected, even though the

potential for informal and flexible learning is increasingly relevant in the digital era.

Critical thinking should be taught at school level, both elementary, middle and even in college. Critical thinking skills are part of analytical skills or higher-order thinking skills and important life skills that need to be nurtured in young minds during the elementary years of education (Khalid et al., 2021; Suardana et al., 2018). Critical thinking skills are highly needed in the 21st century and have been identified as important general skills that contribute to academic and career success (Shaw et al., 2020), therefore they should be taught or trained at all levels of formal education (Elementary, Middle, High School, College). In addition, critical thinking should also be taught to pre-service teachers and prospective teachers, especially in science classes (Physics, Biology, Chemistry). Proponents of teaching critical thinking skills as a specific skill set suggest that it should be taught as a special program that aims to provide learners with theoretical frameworks, concepts, and critical thinking skills. (Yu et al., 2020), stated from a deeper perspective, to complete an engineering design project, the core concepts that high school students must understand include problem analysis and evaluation and exchange of solutions during design planning, this requires critical thinking skills in carrying it out. Where before starting a lecture, students must take pre-engineering courses. Pre-engineering is a course, which requires students to complete an engineering project, focusing on practical and theoretical knowledge, critical thinking, and engineering design thinking. Critical thinking skills support students in making decisions in a certain way during the learning process.

Fajari et al. (2020), conducted a study to improve critical thinking skills in Elementary Schools through three different PBL-assisted learning media seen from students' learning styles. The results of the study revealed that there are various skills in critical thinking in different learning media. The highest skills in critical thinking are achieved by students who are given problem-based learning (PBL) which is different from multimedia in their learning. There are also differences in critical thinking skills between students through visual and auditory.

In college, critical thinking skills are taught from first-year students (freshmen) to final-year students. Kleemola et al. (2022) stated that critical thinking is an important goal of higher education and is important for employment and success in the workforce. Álvarez-Huerta et al. (2022) specifically stated, highlighted the importance of cultivating students' critical thinking dispositions so that they are willing to use critical thinking when there is a problem to be solved or a

decision to be taken, and secondly in order to foster their capacity to appreciate and live with diversity and their confidence in their creative abilities. Critical thinking skills should also be taught to prospective teachers, especially science teachers, and to pre-service teachers.

Critical thinking skills are very important for prospective teachers. Thonney & Montgomery (2019) stated that in higher education, faculty, administrators, and accreditation bodies consider critical thinking as an important student learning outcome. However, assessing student achievement from these outcomes is complicated by challenges. The results of Bilgiler et al. (2019) stated that prospective teachers' metacognitive skills and perceived academic self-efficacy together can explain about half (39.5%) of the variance in their critical thinking tendencies. Furthermore, in terms of their contribution to variance, the two important predictors of prospective teachers' critical thinking tendencies were ranked as metacognitive skills (38%) and perceived academic self-efficacy (1.5%). These results show consistency in learning activities. To summarize, being a teacher is linked to the invaluable potential to promote competencies of several generations of future citizens and thus to make an important contribution to solving future societal issues (Welter et al., 2023).

Which countries have research trends on critical thinking?

From the results of the Systematic Literature Review (SLR) collected, it can be seen that the country with the most research related to critical thinking skills is Indonesia with 19 studies, followed by Malaysia and the USA with 3 studies. The SLR results can be seen in the following histogram:



Figure 4. Histogram of Countries with Critical Thinking Research Trends

From the graph, it can be seen that the research is predominantly conducted in Indonesia. This indicates: a strong local focus in the studies reviewed and the possibility that many articles originate from studies conducted by or in Indonesia, or published by Indonesian researchers. The lack of representation from Africa, the Middle East, and Latin America suggests an

opportunity to expand the scope of research to be more global and inclusive. There is a great opportunity to expand research to other countries so that the results are more diverse and representative of global conditions.

In Sweden, critical thinking skills are a priority curriculum and an important skill in society, so they need to be taught and tested in four compulsory subjects in schools (Nygren et al., 2019). When students face certain problems, critical thinking skills encourage someone to analyze the problem and evaluate possible solutions (Putra et al., 2023). Ma et al. (2023) states that control for student, teacher, and school characteristics, although Chinese eighth graders showed significant critical thinking skills, there was no significant relationship between student and teacher critical thinking. With the same control, there was a statistically significant relationship between student critical thinking and student physics achievement among Chinese eighth graders. Meanwhile, there was no statistically significant relationship between teacher critical thinking and student physics achievement (above the relationship between student critical thinking and student physics achievement).

Specifically in science institutions Richard et al. (2022), conducted a study to evaluate and report on the impact of a school science outreach program on self-reported science knowledge, engagement, and skills through a case study of the Science North school outreach program "Mission to Mars". The logic model method was used to describe the specific inputs, outputs, and measurable outcomes of the program. The program outcomes evaluated in this study were experimental skills, critical thinking skills, and sense of wonder. Results from the pre-post survey indicated that participants' program topic knowledge had increased.

*How are critical thinking skills taught and assessed?
Strategy for teaching critical thinking skills*

Critical thinking skills can be taught through appropriate teaching approaches and strategies. Given the different taxonomies of critical thinking skills, appropriate strategies for teaching critical thinking skills remain to be identified. Different studies have discussed the effectiveness of using specific strategies to improve critical thinking skills such as classroom discussions, problem-based learning, collaborative learning, discussion methods, debriefing techniques, and evidence-based projects. From the SLR data, the learning model that is most often used in critical thinking skills is the inquiry model, followed by STEM, and the least frequently used is the POE (Predict Observe Explain) model. This can be seen as follows:

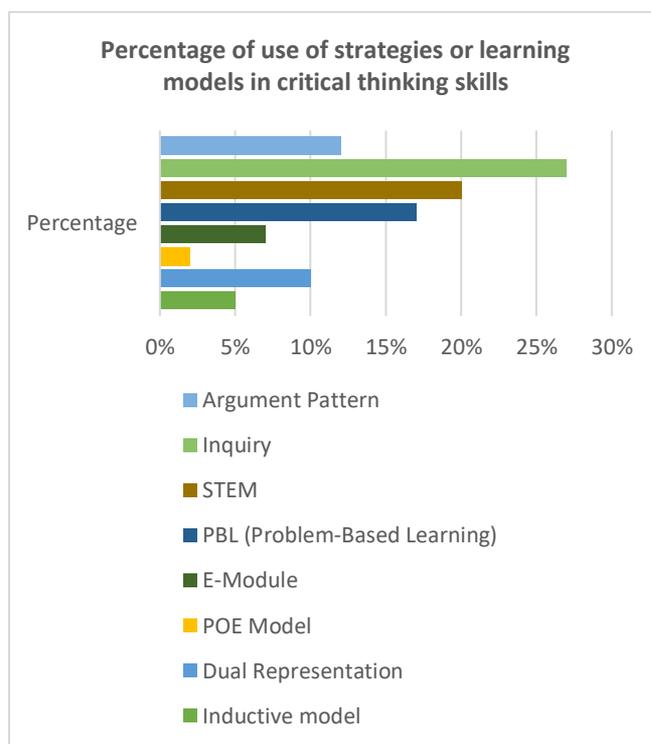


Figure 5. Percentage of use of strategies or learning models in critical thinking skills

From the graph, it can be seen that exploration-based approaches such as Inquiry, PBL, and STEM are used more than digital content-based approaches or formal representations. This shows that educators prioritize active student involvement in building understanding and critical thinking. However, there is still room to improve the use of other strategies such as E-Module and Inductive Model through training and professional development.

Critical thinking is a combination of complex cognitive skills such as problem solving, analysis and evaluation, but it also requires affective dispositions to utilize these skills. Álvarez-Huerta et al. (2022) specifically stated, highlighting the importance of cultivating students' critical thinking dispositions so that they are willing to use critical thinking when there is a problem to be solved or a decision to be made, and secondly to foster their capacity to value and live with diversity and their belief in their creative abilities. Thonney & Montgomery (2019) stated that in higher education, faculty, administrators, and accrediting bodies consider critical thinking as an important student learning outcome. However, assessing student achievement from this outcome is complicated by challenges.

Research conducted by Giri & Paily (2020) reported a study that focused on investigating the effectiveness of the Toulmin argument pattern (TAP) in the scientific argumentation strategy of thinking-reading-group-

reflecting (TRGSR) on the critical thinking of higher secondary students. After carrying out the treatment for 9 weeks, the analysis of covariance findings showed that there was a significant difference in students' critical thinking skills between the experimental and control groups. Students who were in the learning process using the TRGSR scientific argumentation strategy were proven to have increased critical thinking skills. So it was concluded that TAP plus the TRGSR scientific argumentation strategy was relatively more effective in developing critical thinking skills than traditional teaching approaches.

In prospective chemistry teachers, the results of the t-test revealed that Research-Oriented Collaborative Inquiry Learning (REORCILEA) was found to be more effective than the expository teaching model in fostering students' critical thinking skills and science processes. The results of the interviews also showed that students in the experimental group had a more positive perception of reorcilea (Irwanto, 2023). In addition, inquiry learning can also be integrated with ethnoscience to develop the critical thinking skills of prospective science teachers (PST) (Putu Verawati et al., 2022). The results of the study confirmed that in relation to improving critical thinking performance, teaching practices with inquiry-creative learning integrated with ethnoscience were most effective in improving the critical thinking skills of prospective science teachers.

Pursitasari et al. (2020) conducted a study with the aim of improving critical thinking skills through science context-based inquiry learning (SCOIL). The results of the implementation of the SCOIL model showed an increase in critical thinking skills activity with a high category and N-gain categorized at the intermediate level. The significance test showed that students' critical thinking skills with the SCOIL model were greater than the guided inquiry learning model. It can be concluded that the SCOIL model can improve the critical thinking skills of junior high school students. Meanwhile, the results of research conducted by Maknun (2020) showed that the application of the guided inquiry learning model had the ability to significantly improve the understanding of static fluid concepts and critical thinking skills of vocational high school students compared to conventional learning. In addition, the Critique-Driven Inquiry Intervention (ICDI) learning approach also shows that this approach can develop critical and scientific thinking of elementary and secondary school students through inquiry competencies (Lu et al., 2020).

Plummer et al. (2022) conducted a study to improve critical thinking skills through decision-based learning. The results illustrate the possible relationship between the critical thinking components proposed by Facione

(1990) and the learning outcomes promoted by the DBL curriculum. Based on a review of these six publications, a more direct connection can be made between DBL and the four components adopted by Facione (1990) Interpretation, analysis, inference, evaluation. Desnita et al. (2022), stated that there was a significant difference between the levels of creative thinking and critical thinking skills of students who used e-modules in physics learning. Based on the results obtained from the treatment, the application of CTL-based physics e-modules was effective in improving creative and critical thinking skills, as well as student learning outcomes. Alfiyanti & Jatmiko (2020), conducted a study to determine the effectiveness of the Predict Observe Explain (POE) model using PhET to improve critical thinking skills of high school students in physics learning. The data analysis technique used the N-Gain and Wilcoxon tests. The results of the study showed that the scores of students' critical thinking skills in grade XI Group 1 and Group 2 increased after the Implementation of the Predict Observe Explain (POE) Learning Model assisted by PhET and both presented positive responses to the learning components and showed good interest for students.

Chusni et al. (2022), conducted a study to empower critical thinking skills at various academic levels through discovery-based multiple representation learning. The results of the study showed that: DMRL has high potential to improve students' critical thinking skills; students with high competence (HA) have high critical thinking skills; there is an interaction effect between the learning model and various types of achievement on critical thinking skills. Thus, it is concluded that DMRL is effective in closing the gap between students' critical thinking skills and the academic achievement results of students who are at high, medium, and poor competence.

Strategy for assessing critical thinking skills

Educators need instruments to assess and make decisions about how critical thinking skills will impact student achievement. Effective assessment of students' critical thinking skills is a key issue for higher education. The instruments used in these studies (SLR Method) are test and non-test instruments. Educators need instruments to assess and make decisions about how critical thinking skills will impact student achievement. Effective assessment of students' critical thinking skills is a key issue for higher education. The data can be seen in the Figure 6.

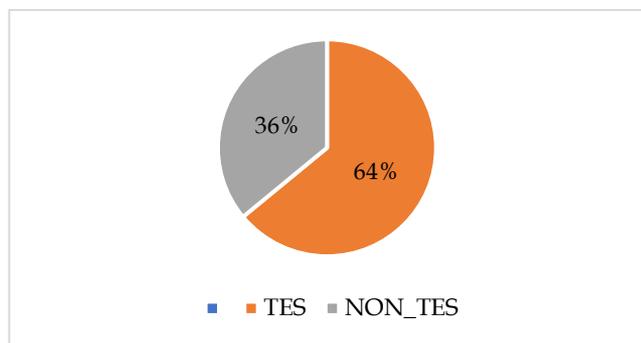


Figure 6. Graphic of critical thinking skills assessment instrument

From the graph above, it can be seen that most critical thinking skills assessments still use the tes method, but the percentage of non-tes use of 36% shows that alternative methods are starting to be adopted. Non-test assessments, which can include observations, project rubrics, portfolios, or authentic assessments, have not been utilized optimally. Further training is needed so that non-test assessments can be used more widely and systematically, especially to measure the process and products of critical thinking authentically. The graph also shows the potential for further development and training for teachers or educational institutions to develop the capacity of non-test assessments in order to evaluate critical thinking skills more comprehensively.

Danczak et al. (2020), conducted a study on the development and validation of an instrument to measure the critical thinking skills of undergraduate chemistry students. This study describes the development and evaluation of a chemistry critical thinking test (Danczak–Overton–Thompson Chemistry Critical Thinking Test or DOT test), set in a chemistry context, and designed to be administered to undergraduate chemistry students at every level of study. The results of the statistical and qualitative analysis indicate that the DOT test is a suitable instrument for use in chemistry education students to measure the development of critical thinking skills. (Al-Mahrooqi & Denman, 2020) conducted a study to assess students' critical thinking skills in humanities and science colleges. This study was developed with an adapted version of the Cornell Classroom Reasoning Test, which uses form x to assess students' critical thinking skills in humanities and science-based colleges. The results showed that participants failed to master or did not master the five principles assessed. However, they recorded significantly higher scores on four of the six item groups than elementary students at the beginning of learning.

Khalid et al. (2021), conducted a study to explore pre-service teachers' perceptions of barriers to efforts to

promote critical thinking skills in the classroom, and further explore possible solutions to overcome perceived barriers. Data collection was carried out through an online survey and continued with focus group discussions to further explore the results of quantitative data. The conclusions of this study suggest changes in the teaching course methods offered in teacher preparation programs and changing perceptions of critical thinking skills, in addition to changing steps to promote the development of critical thinking skills in the classroom.

Can technology improve students' critical thinking skills?

By utilizing technology appropriately, students can develop essential critical thinking skills in problem solving, analysis, evaluation and decision making. It is important to combine technology with teaching approaches that promote reflection, dialogue and active engagement of learners to achieve optimal results. Putra et al. (2023) conducted research on exploring students' critical thinking skills using the engineering design process in physics classes. The research results show that the engineering design process (EDP) can improve students' critical thinking skills and can be an alternative method for training critical thinking skills. In the era of the Covid-19 pandemic, technology has an important role in helping the learning process take place. Jean Sombria et al. (2022) researched the effectiveness between independent learning modules and online learning via Google Classroom, and the results showed that students' level of critical thinking ability increased because they used online learning compared to a modular approach. From the SLR results, data was obtained that technology can improve students' critical thinking skills both at elementary and university levels. Of the 50 articles in the SLR, there are 38 articles (76%) that discuss the use of technology in the learning process and 12 articles (24%) that discuss the learning process. This can be seen in the following graph:

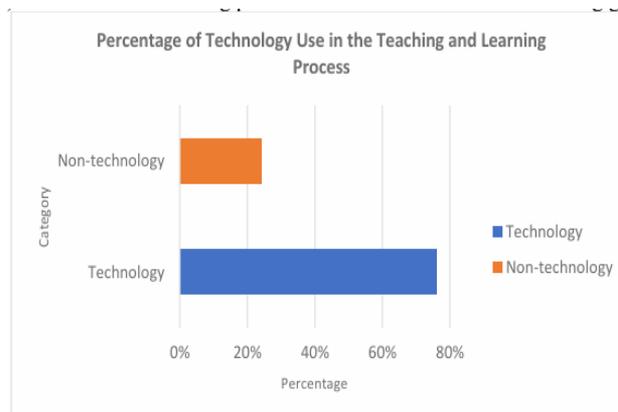


Figure 7. Graph of the percentage of technology use in the teaching and learning process

It can be seen that the integration of technology in teaching and learning process is very dominant, indicating a shift in the educational paradigm towards a more modern and digital approach. However, attention is still needed to the gap in access and readiness in implementing technology evenly. Currently, the need for individuals who follow science and technology is growing closely and increasing. This need makes countries need to try various changes, reforms, and approaches needed in their education systems. The development of digital-based science is starting to be carried out and researched. During the Covid-19 pandemic, the need for technology has increased significantly in the field of education. Technology helps students and educators stay connected and can carry out learning remotely.

Dewi et al. (2019), conducted research on the development of digital storytelling based on contextual teaching materials to improve students' critical thinking. Based on the results of the study, it was concluded that the science digital storytelling (SDS) learning media developed has the characteristics of audio-visual media and meets seven good components; contextual-based SDS learning media on theme classification is declared suitable for use in junior high school science learning in terms of media and materials aspects, and is also significantly beneficial for improving students' critical thinking. Hussein et al. (2019) designed a computer-based educational game called *Ecoship Endeavor*, where the basis of the game design is to conduct investigation, communication, mystery, decision-making, challenges, and rewards (ICMDCR), while the framework is to help facilitate critical thinking skills in students. To test the effectiveness of this program, a digital game-based learning (DGBL) approach was applied. The results of the experiment revealed that *Ecoship Endeavor* significantly improved students' critical thinking skills. However, it was also revealed that DGBL activities did not have a significant effect on students' learning motivation and self-efficacy for science learning.

In addition, Alfiyanti & Jatmiko (2020), conducted a study aimed at determining the effectiveness of Predict Observe Explain (POE) observation with PhET to improve critical thinking skills of high school students. The results of the study showed that the critical thinking ability scores of eleventh graders group 1 and group 2 increased after the implementation of the Predict Observe Explain (POE) learning model with PhET and both gave positive responses to the learning components and showed good interest.

Jodoi et al. (2021) developed an active learning application to improve critical thinking through item selection and gamification. Critical thinking (CT) is widely recognized as an important skill and attitude in

the modern world, but few applications (web-based or installed on devices) have been developed to train it effectively, whereas the findings of this study suggest that CT applications can be effectively developed using existing question banks, although the effects of gamification require further research. Lamb et al. (2021), have studied an example of a Computational Modeling (CM) experiment using a machine learning algorithm. The computational results of the model experiment provide the possibility of improving student success through targeted cognitive retraining of specific cognitive attributes through SWH or scientific writing heuristics.

STEM also had an impact when the Covid-19 crisis hit the world. Where almost all learning uses technology for the learning process. Information and computing technology plays a role in processing data, managing information, and supporting communication during the pandemic. Hebebcı & Usta (2022) integrated STEM education into the learning process to determine its effect on problem-solving skills, scientific creativity, and critical thinking skills dispositions. The results of the study revealed that the application of integrated STEM education had a positive effect on students' problem-solving skills, scientific creativity, and critical thinking dispositions.

Prayogi et al. (2022), conducted a study on the application of the ethno-inquiry model in an e-learning platform and evaluated its impact on the critical thinking skills of prospective science teachers. The results showed that the ethno-inquiry model had a significant influence on the critical thinking skills of participants. Arjunaidi & Azid (2022) conducted a study on the implementation of the Inductive Model on students' critical thinking skills in science during online learning. The results of their study showed that students' critical thinking achievements in science in the treatment group increased significantly based on the post-test results, and qualitatively, this study also found that students felt happy and motivated (more interested, and fascinated) through the inductive learning session, and improved their critical thinking skills.

Desnita et al. (2022), conducted a study on the effectiveness of CTL-based physics e-modules on students' critical thinking skills in high school. The results showed that the scores of students' creative and critical thinking skills in the experimental group at the end of the treatment were 81.85 and 81.81. This means that CTL-based physics e-modules are effective in students' critical thinking skills. Hasanah et al. (2023), conducted an investigation into teachers' perceptions of the need to use multimedia in science learning to improve students' critical thinking in Elementary Schools. It was concluded that interactive multimedia

based on scientific inquiry in science learning is feasible to be developed and implemented in the teaching and learning process.

Giancarlo & Facione (2001) state that critical thinking has a conceptual relationship with reflective judgment, problem framing, higher order thinking, logical thinking, decision making, problem solving, and the use of scientific methods. Several studies have been conducted relating to what skills should be taught, including: assessment validation skills (Shaw et al., 2020), metacognitive skills (Hussein et al., 2019), interaction skills in the learning process (Indrašienė et al., 2021), epistemic skills on unwarranted beliefs (Dyer & Hall, 2019), exploration and self-regulated skills (Anwar & Muti'ah, 2022), mastery of concepts (Suciati et al., 2022), Misconceptions (Maison et al., 2022), scientific skills pedagogy (Cornejo et al., 2022), questioning (Nur et al., 2023), and predicting (Alkharusi et al., 2019). Providing students with opportunities to practice and apply these skills in real contexts will help them develop strong critical thinking skills.

Conclusion

Critical thinking skills must be taught and practiced at school level, both in elementary school, high school, and in certain courses. Research trends on Critical Thinking Skills (CTS) in various countries show interesting dynamics, reflecting the educational priorities and academic policy directions of each region. Critical thinking skills are taught using appropriate learning models or strategies, for example using the Toulmin Argument Pattern (TAP) approach, inquiry models with various approaches (REORCILEA, integrated with ethnoscience, SCOIL, ICDI), Decision-Based Learning (DBL), Predict Observe Explain learning (POE), Discovery-based Multiple Representation Learning (DMRL) so that they can produce positive and good impacts on the learning process. The process of assessing critical thinking skills must be produced from the right instrument so that it can assess every aspect of critical thinking skills properly. In this 21st century, technology can help the learning process become better, easier, and more interesting, so that it is expected to improve students' critical thinking skills.

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Author Contributions

Conceptualization, methodology, formal analysis, investigation, resources, data curation, and original draftwriting: A.S.R., ; validation, review and editing, and

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Conflicts of Interest

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