Exploring High School Students' Critical Thinking Skills Using Active Learning: A systematic Literature Review

(Eksplorasi Keterampilan Berpikir Kritis Siswa SMA Menggunakan Pembelajaran Aktif: Tinjauan Literatur)

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Abstract——**This article aims to explore understandings that lead to critical thinking skills possessed by senior high school students. The method involves a careful selection of articles published in journals indexed scopus Q1 until Q4. This methodology uses a systematic literature review by exploring research conducted during 2018–2023 and using descriptive statistics to analyze data to develop learning strategies or learning media that can improve critical thinking skills. The final sample included 50 articles, the Journal of Technology and Science Education was the most productive journal. The findings show that effective mediators in active learning for improving critical thinking skills include (1) learning models that encourage class interaction, (2) use of learning media, and (3) teaching strategies. Therefore, this article concludes with a summary of relevant recommendations to advance learning that leads to increased critical thinking skills of senior high school students.**

Keywords— Critical thinking skills, Active learning, Systematic Literature Review

I. INTRODUCTION

Humans must thinks, everyone thinks, but not everyone thinks well, and not all educators teach their students how to think well [1], [2], [3]. The importance of developing critical thinking in students has been suggested as the most important skill that education systems can develop in students [4]. Good thinking or thinking well is often associated with critical thinking [1], [5], but when a clear definition of critical thinking or how students can develop it is unknown, This claim is insufficient. So we ask: What is critical thinking?

Critical thinking has been defined in many different ways. Some authors suggest that critical thinking is more than good thinking. Instead, think in terms of logic and reasoning [6], [7], [8]. Some focus on critical thinking as a mental process used to make decisions and solve problems [9], [10]. These ideas suggest that critical thinking is about giving your beliefs and actions justification. A key component of critical thinking is therefore applying the skill of assessing whether an argument is good or bad by assessing whether a hypothesis supports a conclusion.

While there is little disagreement about the value of critical thinking [10], many scholars note that teaching critical thinking across the curriculum is diverse and challenging [11], [2], [6]. According to [11], [12], if you are to think critically, you must have a sound knowledge base of the problem or topic of enquiry and view it from multiple perspectives. Solving a problem at a surface level requires limited prior knowledge and will not necessarily require critical thinking. In contrast, solving a problem critically requires looking at its deep structure to understand it from different viewpoints. While it is a frequent practice in the preschool classroom to engage children in diverse ways to view the world, pedagogies to scaffold how children see the world from different perspectives are interwoven into curricula rather than identified as an explicit learning goal.

II. THEORETICAL FRAMEWORK

A. Objectives

The main objectives of this systematic review are to:
• Exploration of improving the thinking skills of middle and upper students
• Factors that can improve critical thinking skills

This review does not intend to delve into the complexities of critical thinking skills as a broad concept, rather we seek to clarify ways of enhancing critical thinking skills. Nevertheless, it is important to provide an overview of the concept before exploring how critical thinking is in senior high school students.

This paper is organised in the following way: Section 1 provides an overview of critical thinking including related skills and definitions that reflect on the importance of critical thinking in early childhood; Section 2, the methodology, provides details of the systematic review of the literature; Section 3, presents the key results; Section 4, discusses the

reviewed literature to reflect on the implications of the findings to enhance early years research and practice; Section 5 presents a conclusion and recommendation for future research on developing critical thinking with young children in a pedagogical context.

Critical thinking skills can be improved by practicing critical thinking indicators in the learning process [6]. Based on the literature review, the components contained in the learning process that affect students' critical thinking skills are learning models, learning media, and learning approaches. The combination of models, media, and well-planned, implemented, and evaluated learning approaches will produce good learning strategies. A good learning strategy will create active learning. If the active learning process is combined with training indicators of critical thinking skills, continuous learning will be able to improve students' critical thinking skills. The relationship between models, media, and interactive learning approaches is illustrated in Fig 1.
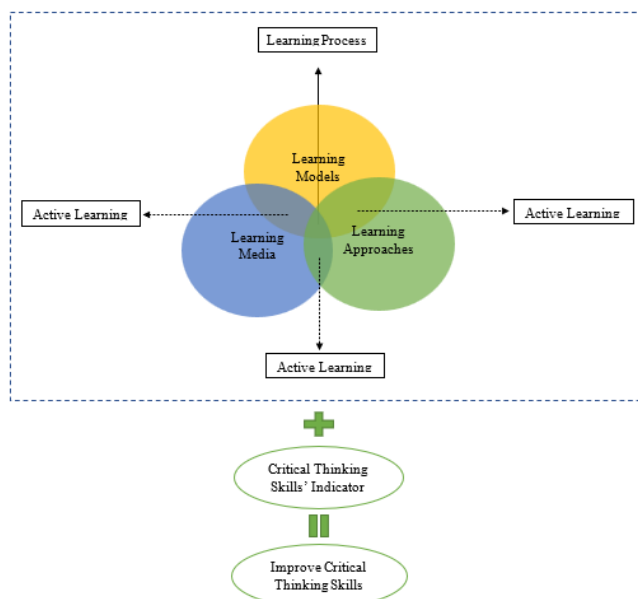

Fig. 1. framework of relationships between factors that improve critical thinking skills

B. Overview of critical thinking

Definitions of critical thinking sometimes overlap between disciplines, this review will focus on the field of education. More specifically, the focus of this review is on critical thinking skills in senior high school education. We limit our review to studies conducted in higher education. In it, the first part of this section considers critical thinking as a broad concept as we seek to explore the literature to uncover what is known about critical thinking skills in higher education.

Critical thinking in education has been a focus of attention in research and pedagogy for more than 100 years. Emphasized by John Dewey as a goal of education, Flores & Kyere also propose that developing critical thinking will empower students to become just-minded and democratic members of society. [13], [14]. For Wahyuni et al.[15], teaching critical thinking must begin by motivating students to actively and continuously consider the characteristics of a problem based on the information available to them. Many researchers

agree with Dewey's suggestion that critical thinking starts with students' involvement with a problem. For example, Mohammadi [16] describes critical thinking as a mental process that people use to solve problems, make decisions, and learn new concepts.

However, critical thinking scholars propose that skills alone are not enough, on the contrary, skills and thinking dispositions are necessary to become a critical thinker [17], [18], [19]. Indeed, most researchers agree that critical thinking skills and dispositions are intrinsically linked. In comparison, a critical thinking disposition is a tendency to be fair and open-minded, to separate facts from assumptions or bias, and to be open to multiple points of view (eg, Gunawan et al., 2019; Kozikoğlu, 2019).

C. Active Learning

Prior reviews have determined that one that is able to improve critical thinking skills is active learning. In this review, we define active learning as classroom-based activities designed to engage students in their learning through answering questions, solving problems, discussing content, or teaching others, individually or in groups [20], [21], [22].

Previous studies show that students perceive active learning as a benefit of their learning [23], [24], [25] and increases their self-efficacy [26], [27]. In addition, the use of active learning has been associated with improving students' critical thinking skills and learning [4], [6].

Despite ample evidence in favor of active learning, previous research has found that traditional teaching methods such as lectures are still the dominant mode of teaching in schools, and low adoption rates of active learning in high schools remain a problem [28]. There are several reasons for this low adoption rate. Some instructors feel unsure that the effort required to implement active learning is worthwhile, and as many as 75% of instructors who have tried a particular type of active learning abandon the practice altogether [29], [30].

D. Systematic Literature Review

A systematic study of the literature to build new ideas or models from current theories is known as an integrated literature review [10], [11]. This review seeks to explain and reveal the potential of learning strategies to develop students' critical thinking skills more comprehensively. In addition, it also recommends focusing on future studies with increased active learning processes in the classroom.

III. METHOD

A. Research Question

The SLR method was used to analyze experiments conducted to improve critical thinking skills between 2018 and 2023. SLR makes it possible to map and access existing intellectual areas, in addition to defining research questions to develop existing body knowledge [31], [32]. Therefore, this study seeks to answer the following questions:

Research Question 1 (RQ1): What are the learning characteristics of the most relevant experiments to improve critical thinking skills published recently?

Research Question 2 (RQ2): How should CT skills be taught and assessed?

These questions are defined with the support of the literature, which shows the breadth of learning strategies that enhance critical thinking skills, as in Wenno, dkk., Yulianti, and Rapi [33], [34], [35]. The SLR's development was based on a research protocol, because it requires great methodological rigor to neutralize research bias, by making explicit the values and hypotheses that underpin the review [5], [8]. Thus, the research protocol by Tranfield et al. [36] was followed, which is composed of three stages: review planning, review conduction, and dissemination of knowledge.

B. Stage 1: SLR Planning

The first phase of the SLR consists of its planning, which entails identifying the need for review, preparation of articles accepted for review, and finally, development of a research protocol. Verified that no published SLRs involve the terms "improved critical thinking skills" and "experiments"; then, the article was elaborated and a protocol was developed, containing information on the specific issues addressed by the study, the sample, and criteria for inclusion of the study in the SLR, as suggested by Tranfield et al. [36]. A protocol is a plan that ensures research objectivity by explicitly describing the steps to be taken [37], [38].

C. Stage 2: Conducting the SLR

The second step is to carry out an article search in a comprehensive and impartial way, choosing keywords that best align with the research question[37], [38]. Searches using keywords in the English language that characterize improving critical thinking and experiments were carried out in two journal databases, WOS and Scopus. The search string TS = ("improving critical thinking*" AND "experiment*") was used in WOS, and the string used in Scopus was TITLE-ABSKEY ("improving critical thinking*" AND "experiment*").

As the subject of improving critical thinking and experiments is broad, some restrictions were applied. Only articles written in English were chosen. They must fit into certain areas of the SCImago Journal Ranking (SJR)-education. They must be published between 2018 and 2023. Journals must belong to Q1 and Q4 of the SJR (to capture only the most relevant journals). Duplicate articles were taken from one of the databases; and titles, abstracts, and keywords of the articles were read to ensure that they fitted the topic. In the paper selection process, the desired areas/subjects and quartiles were defined previously, both from SCImago. From the articles that emerged in the filtering, each of the journals in which the papers were published were consulted in the SCImago's website, to know which areas and quartiles the journals belonged to Fig. 2 presents the flowchart of the articles' selection.
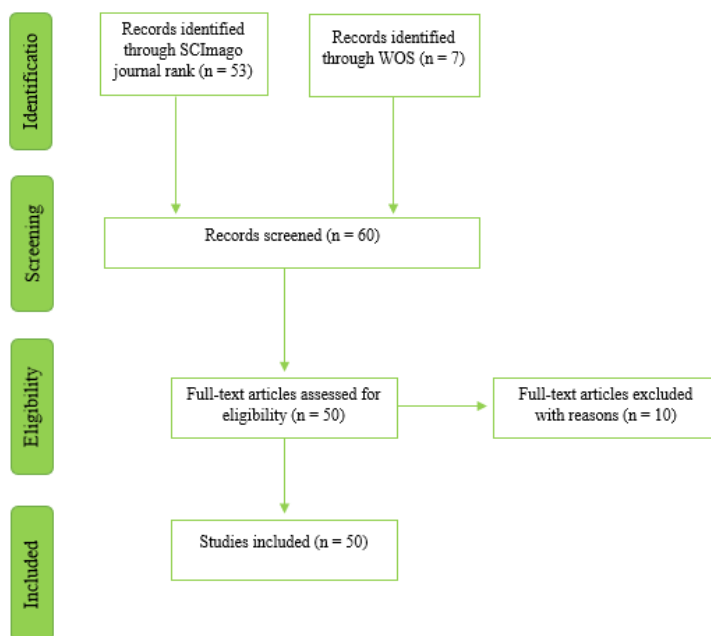

Fig. 2. Flowchart of the textual corpus selection process

The search was carried out on Scopus and WOS indexed journals. Based on your search we found 7 results in WOS, while 53 results in Scopus. After the application of all search filters, 7 articles in the WOS and 43 in the Scopus database remained, totaling 50 articles that compose the research corpus, published in 30 journals.

Selected articles were grouped in a spreadsheet and data regarding citation indicators and content of each study were extracted. For the citation indicatorsthere are six items: year of publication, journal in which it was published, topic, sample/participant, and level study, and methodology.

D. Stage 3: Dissemination of knowledge

The third stage is the dissemination of results. According to Tranfield et al.[36], through this stage, there is the generation of knowledge. This stage comprised the detailed analysis of characteristics of the papers composing the research corpus, based on data collected in the citation indicators. The spreadsheet and HistCite [39] software were used.

At this stage, the following tasks were undertaken: (a) verifying the number of publications per year, (b) examining which journals are the most relevant in the topic, (c) knowing the countries and institutes to which the authors are affiliated, (d) analyzing the authorship composition of the papers, and (f) performing author's cocitation and bibliographic coupling analyses. Tranfield et al. [36] and Valcanover [40] pointed these tasks as fundamental for an SLR.

From 2018 to 2022 there tends to be a gradual increase in the number of articles published, from 6 articles (13.95%) in 2018, decreasing to five articles (11.63%) in 2019 and 2020. However, the number of articles has increased quite a bit. significant in 2020 with 10 articles (23.26%) relevant, or there may be more publications in journals belonging to other citation sites (Q1 to Q4), which are not part of the sample because they do not represent the topic.
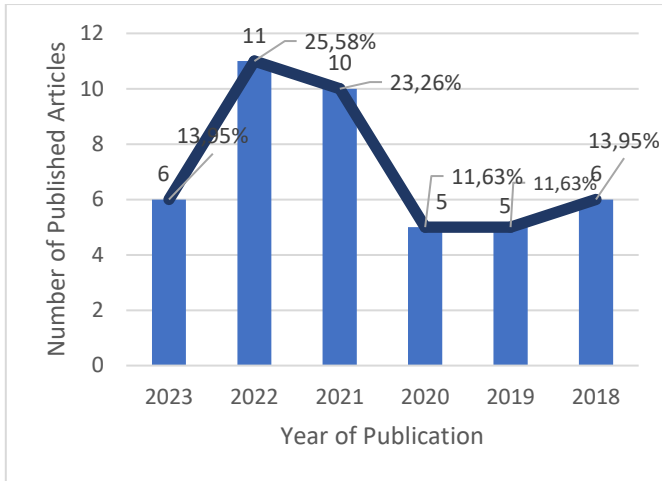
Fig. 3. Distribution of articles published per year between 2018 and 2023

IV.   ANALYSIS OF SLR RESULTS

A. Distribution of the Textual Corpus Per Year

The first step of the analysis shows the distribution of articles published during the studied period, 2018 to 2023. As observed in Figure 3, there was great variation in the frequency of publication of articles on the improving critical thinking students.

Based on review, during 2022, 11 articles (25,58% of the sample) were published, being the period with the highest number of published papers for the entire period. The paper by Mafarja et al. [34], titled "Using Reciprocal Teaching Strategy to Improve Physics Students' Critical Thinking Ability," published in 2022 in EURASIA Journal of Mathematics, Science and Technology Education, achieved a total of 66 citations worldwide until the data collection to this paper was completed, being the most cited paper of the textual corpus.

Table 1. Analysis of the Journals' Reputation

Journal	Number of articles	SJR Quartile	SJR Index	H index	Country
Journal of Technology and Science Education	5	Q2	0.52	17	Spanyol
Jurnal Pendidikan IPA Indonesia	4	Q3	0.36	23	Indonesia
EURASIA Journal of Mathematics, Science and Technology Education	3	Q2	0.51	50	Turkey
International Journal of Interactive Mobile Technologies	3	Q3	0.41	29	Austria
Thinking Skills and Creativity	2	Q1	1.15	58	Belanda
Cypriot Journal of Educational Sciences	2	Q3	0.22	13	Cyprus
International Journal of Instruction	2	Q2	0.61	32	Switzerland
Journal of Turkish Science Education	2	Q2	0.44	21	Turkey
Physical Review Physics Education Research	2	Q1	1.02	37	US
International Journal of Evaluation and Research in Education	2	Q3	0.31	14	Indonesia
Asia-Pacific Forum on Science Learning and Teaching	1	Q4	0.1	17	Hong Kong
Malaysian Online Journal Of Educational Management	1	Q4	0.16	5	Malaysia
Journal of Hunan University (Natural Sciences）	1	Q2	0.24	19	China
European Journal of Educational Research	1	Q3	0.34	18	Belanda
Asia-Pacific Education Researcher	1	Q1	0,99	37	Singapura
Research in Science & Technological Education	1	Q1	0.61	36	UK
International Journal of Science Education	1	Q1	1	121	UK
Computer Applications in Engineering Education	1	Q1	0.65	37	US
Knowledge Management & E-Learning	1	Q2	0.68	26	China
International Journal of Educational Methodology	1	Q4	0.13	2	US
International Journal of Information and Communication	1	Q2	0.38	19	US

Technology Education					
International Journal of Cognitive Research in Science, Engineering, and Education	1	Q3	0.28	14	Serbia
Revista mexicana de fisica	1	Q3	0.31	30	Mexico
TEM Journal	1	Q3	0.23	17	Serbia
International Journal of Science and Mathematics Education	1	Q1	1.06	51	Belanda
Science & Education	1	Q1	2.12	127	US

B. Reputation of Textual Corpus Journals

The second analysis concerns the characteristics of the 27 journals indexed scopus in which the articles of the research corpus were published. Table 1 shows a list with the journals' names, the number of articles published in each of them during the period, the SJR quartile to which they belong, their SJR and H indexes, and their countries of origin. Such indexes help to verify the productivity and relevance of journals.

In the period studied, the Journal of Technology and Science Education published the highest number of articles (5 articles, 18% of the sample), being the most relevant journal. This figure is quite expressive, because the second most productive journal is the Indonesian Science Education Journal with four articles (15%) followed by EURASIA Journal of Mathematics, Science and Technology Education & Organization, and International Journal of Interactive Mobile Technologies each with only three articles (11%). Other journals publish an article or two. For the SJR classification quartile, 8 journals are included in the Q1 citation quartile (30% of total journals), while seven are in Q2 (26%). The most productive journal is located in Q3. There are 9 journals included in the Q3 citation quartile (33% of the total journals). While there are only 3 journals that are included in the q4 citation quartile.

For the SJR and H indices, Science & Education has the highest SJR and H indices, while this journal only publishes one article in the sample. Regarding the country of origin of the journal, four came from England (15.38% of the sample) which is the most of the sample. Furthermore, the analysis of journals' productivity is supported by Bradford's [7], [35] law, because it was possible to visualize that the logarithm of the cumulative number of journals and the cumulative number of papers formed an approximately S-shaped graphic.

C. Distribution of Textual Corpus Authors by Country

Subsequently, the articles' authorship was analyzed. According to HistCite software, the total number of authors is 128, distributed among the 50 articles in the database. Regarding the authors' place of work, Figure 4 presents its distribution by country.

As observed, the 128 authors are scattered in 12 countries. Furthermore, the most authors work in institutions located in the Indonesia with 88 authors (68.75% of the total). In second place, United States has 9 authors (7.03%), whereas Malaysia has 7 authors (5.47%), India has 5 authors (3.91%), Philippines, China, Belgium Italy each have 4 authors (3.13% each) participating in their institutions, Turkey has 3 authors (2.34%), and Mexico, UK, Saudi Arabia, and Ethiopia each just have 1 authors (0.78% each) participating in their institutions.
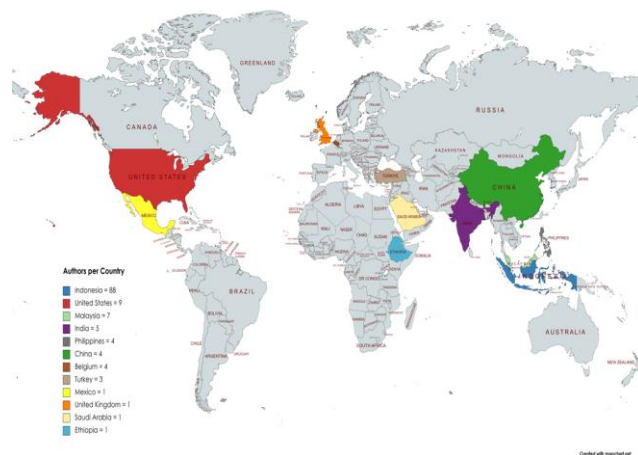

Fig 3. Distribution of authors of the textual corpus by country

D. Selection of Physics Topics

Distribution of selection of physics material is determined based on urgency related to critical thinking skills. Figure 4 presents a table that illustrates the amount of material selected which is associated with critical thinking skills.
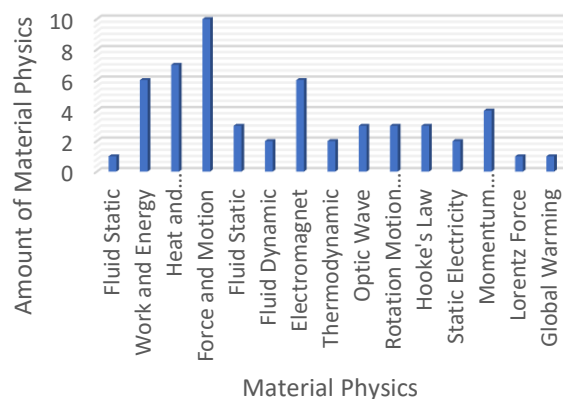

Fig 4. The amount of physics material used as a research topic

Based on the graphs presented, it can be seen that the most force and motion material (18.5%) is used as a research topic related to critical thinking skills at all levels of education. Followed by heat and temperature (13%) as the second most material chosen as a research topic.

E. Analyses of Topic

Based on the topic relationship title search using the VOS Viewer, critical thinking skills are widely studied with other variables. Figure 4 illustrates the relationship between critical

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thinking skills in physics and other variables, such as critical thinking skills that must be possessed by senior high school students, their implementation in physics concepts, and the use of learning models that can improve students' critical thinking skills.

Fig 4. Topic network.
Source. Prepared by the authors. Created with VOSviewer

F. Pedagogical Approaches

Across the 50 papers, there was a significant variation in the teaching and learning approaches applied in the classroom. We grouped these approaches under educational disciplines; Physics. The pedagogical approaches used across the studies are diverse in their design providing the children with different levels of instruction to interact with a task or activity. Nevertheless, there are commonalities within the application of the methods. For example, all the approaches involve the role students and encouraging them to share their ideas concerning a task or activity. Consequently, at some level, all of the above are encouraging active learning.

Paul and Elder [8] propose that if an educator teaches a students how to think critically, the educator must explicitly understand what they are teaching and explain this with clarity to the learners. Evidence of explicit instruction was demonstrated in four studies that promoted thinking language and modelling thinking skills in the classrooms [4], [27], [32]. While in Kustyarini [29] observational study, findings also referred to the impact of active learning. Results from this study suggest that a range of classroom interactions promote critical thinking when the educators are aware of the concept of critical thinking. In Kustyarini's study, the participating educators had taken a training course on conceptual pedagogy.

Based on the literature review, we summarize three main points that can improve students' critical thinking skills which can be seen in the table 2.

Component Process Learning	SJR Quartile				Percentage
	Q1	Q2	Q3	Q4	
Learning Model	5	7	9	-	48.84%
Learning Media	3	2	1	2	18.60%
Learning Approaches	2	6	5	1	32.56%

Based on the literature review that has been done, it can be seen that the learning model has the biggest role in improving critical thinking skills (48.84%), followed by learning approaches (32.56%), and learning media (18.60%). These three components are of great concern to always be evaluated

for the realization of active learning that is able to improve students' critical thinking skills.

V. CONCLUSIONS

Scholars emphasise that if critical thinking is to be explored in the learning environment, a clear and accurate conceptualisation of its characteristics is essential [16], [30]. By highlighting characteristics of critical thinking by naming the skills of reasoning and problem solving (see Table 2), we now have a clear baseline from which we can develop pedagogies that suit the context in which we teach. In doing this, the review has identified learning processes in senior high school everyday experiences that educators, through awareness, can support.

The results of the systematic review strongly suggest that critical thinking can be developed through active learning in learning process when educators know what learning components need to be evaluated and followed up for sustainable learnings (see Table 2). This review has reinforced messages from the literature recognising the importance of developing critical thinking skills during the school years [6]. Thus, we recommend that the research gap identified in respect of higher education could be addressed by investigating learning process that could include further research investigating how experiment method as pedagogy could scaffold critical thinking skills in higher education.

REFERENCES

[1] Pithers, R. T., & Soden, R. (2000). Critical thinking in education: A review. Educational Research, 42(3), 237-249.

[2] Djamas, D., Tinedi, V., & Yohandri. (2018). Development of Interactive Multimedia Learning Materials for Improving Critical Thinking Skills. International Journal of Information and Communication Technology Education, 14(4), 66-84.

[3] Asrizal, Mardian, V., Novitra, F., & Festiyed. (2022). Physics electronic teaching material-integrated STEM education to promote 21st-century skills. Cypriot Journal of Educational Sciences, 17(8), 2899-2914.

[4] Saputra, M. R. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K., B. (2019). Developing Critical-Thinking Skills through the Collaboration of Jigsaw Model with Problem-Based Learning Model. International Journal of Instruction, 12(1), 1077-1094.

[5] Zhou, Z. (2022). Critical Thinking: Two Theses from the Ground Up. Journal of the Scholarship of Teaching and Learning, 22(1), 154-171.

[6] Maison, Hidayat, M., Kurniawan, D. A., Yolviansyah, F., Sandra, R. O., & Iqbal, M. (2022). How Critical Thinking Skills Influence Misconception in Electric Field. International Journal of Educational Methodology, 8(2), 377-390.

[7] O'Reilly, C., Devitt, A., & Hayes, N. (2022). Critical thinking in the preschool classroom-A systematic literature review. Thinking Skills and Creativity, 46, 101110.

[8] Paul, R., & Elder, L. (2019). The thinker's guide to socratic questioning. California: Rowman & Littlefield.

[9] Dahdal, S. (2020). Using the WhatsApp Social Media Application for Active Learning. Journal of Educational Technology Systems, 49(2), 239–249.

[10] Ma, X., Zhang, Y., & Luo X. (2021). Students' and teachers' critical thinking in science education: are they related to each other and with physics achievement?. Research in Science & Technological Education, 41(2), 734-758.

[11] Wibowo, F. C. (2023). Effects of Augmented Reality Integration (ARI) Based Model Physics Independent Learning (MPIL) for Facilitating 21st-Century Skills (21-CS). Journal of Technology and Science Education, 13(1), 178-192.

[12] Willingham, D.T. (2007). Critical thinking: Why it is so hard to teach?. American federation of teachers summer 2007, 8–19. Abidin, A. Z., Istiyono, E., Fadilah, N., & Dwandaru, W. S. B. (2019). A computerized adaptive test for measuring the physics critical thinking skills.
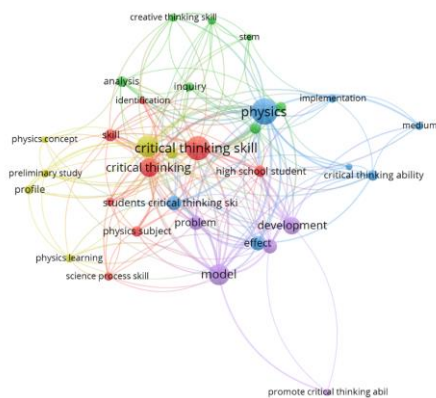
International Journal of Evaluation and Research in Education, 8(3), 376-383.

[13] Desnita, Festiyed, Novitra, F., Ardiva, A., & Navis, M. Y. (2022). The Effectiveness of CTL-based Physics E-module on the Improvement of the Creative and Critical Thinking Skills of Senior High School Students. TEM Journal, 11(2), 802-810.

[14] Dewi, P. S. & Kuswanto, H. (2023). The Effectiveness of the Use of Augmented Reality-Assisted Physics E-Module Based on Pedicab to Improve Mathematical Communication and Critical Thinking Abilities. Journal of Technology and Science Education, 13(1), 53-64.

[15] Wahyuni, S., Sanjaya, I. G. M., Erman, E., & Jatmiko, B. (2019). Edmodo-Based Blended Learning Model as an Alternative of Science Learning to Motivate and Improve Junior High School Students' Scientific Critical Thinking Skills. International Journal of Emerging Technologies in Learning (iJET), 14(07), 98–110.

[16] Mohammadi, M. & Pouya, N. D. (2021). The Relationship between EFL Learners' Mental Toughness and Critical Thinking. Journal of Social Science and Humanities Research, 9(2), 25-36.

[17] Faridi, H., Tuli, N., Mantri, A., Singh, G., & Gargrish, S. (2020). A framework utilizing augmented reality to improve critical thinking ability and learning gain of the students in Physics. Computer Applications in Engineering Education, 29(1), 1-16.

[18] Anindhyta, C., Sunarno, W., & Budiawanti, S. (2021). Physics Virtual Learning Simulation to Enhance Students' Critical Thinking Skill: Virtual Learning during the COVID-19 Pandemic. Journal of Hunan University (Natural Science), 48(5), 157-163.

[19] Brinkmann, S. (2022). Thinking and the Moral Landscape. Culture and Psychology, 28(2), 188-199.

[20] Serevina, V., Nugroho, D. A., & Lipikuni, H. F. (2022). Improving the Quality of Education Through Effectiveness of E-Module Based on Android for Improving the Critical Thinking Skills of Students in Pandemic Era. Malaysian Online Journal of Educational Management, 10(1), 1-20.

[21] Almulla, M. (2018). Investigating Teachers' Perceptions of Their Own Practices to Improve Students' Critical Thinking in Secondary Schools in Saudi Arabia. International Journal of Cognitive Research in Science, Engineering and Education, 6(3), 15-27. Alsaleh, N. J. (2020). Teaching critical thinking skills: Literature review. Turkish Online Journal of Educational Technology, 19(1), 21–39.

[22] Arafah, K. & Hakim, A. (2022). The effect of epistemological understanding of physics on students' critical thinking skills. Cypriot Journal of Educational Science, 17(10), 3778-3794.

[23] Bezanilla, M. J., Fernández-Nogueira, D., Poblete, M., & Galindo-Domínguez, H. (2019). Methodologies for teaching-learning critical thinking in higher education: The teacher's view. Thinking Skills and Creativity, 33, 100584.

[24] Damayanti, A. E. & Kuswanto, H. (2021). The Effect of the Use of Indigenous Knowledge-Based Physics Comics of Android-Based Marbles Games on Verbal Representation and Critical Thinking Abilities in Physics Teaching. Journal of Technology and Science Education, 11(2), 581-593.

[25] Diani, R., Irwandani, Al-Hijrah, Yetri, Fujiani, D., Hartati, N. S., & Umam, R. (2019). Physics Learning through Active Learning Based Interactive Conceptual Instructions (ALBICI) to Improve Critical Thinking Ability. Jurnal Penelitian dan Pembelajaran IPA, 5(1), 48-58.

[26] Ennis, R. (2011). Critical thinking: Reflection and perspective Part II. Inquiry: Critical Thinking Across the Disciplines, 26(2), 5-19.

[27] Ennis, R. H. (1987). Critical thinking and the curriculum. Thinking Skills Instruction: Concepts and Techniques, 40-48.

[28] Facione, P. A. (2011). Critical thinking: What it is and why it counts. Insight Assessment, 2007(1), 1-23.

[29] Febriani, Jumadi, & Dwandaru, W. S. B. (2023). Socio-scientific issues in physics learning to improve students' critical thinking skills. Revista Mexicana de Fisica, 20(1), 1-6.

[30] Fisher, R. (2001). Philosophy in primary schools: Fostering thinking skills and literacy. Reading, 35(2), 67-73.

[31] Flores, O.J. & Kyere, E. (2021) Advancing Equity-Based School Leadership: The Importance of Family–School Relationships. Urban Review, 53, 127–144.

[32] Froyd, J. E., Borrego, M., Cutler, S., Henderson, C., & Prince, M. J. (2013). Estimates of use of research-based instructional strategies in core electrical or computer engineering courses. IEEE Transactions on Education, 56(4), 393– 399.

[33] Wenno, I. H., Limba, A., Silahoy, Y. G. M. (2022). The development of physics learning tools to improve critical thinking skills. International Journal of Evaluation and Research in Education, 11(2), 863-869.

[34] Yulianti, D., Sugianto, & Ngafidin, K. M. (2022). Scratch Assisted Physics Learning With A STEM Approach in the Pandemic Era to Develop 21st Century Learning Skills. Jurnal Pendidikan IPA Indonesia, 11(1), 185-194.

[35] Rapi, N. K., Suastra, I. W., Widiarini, P., & Widiana, I. W. (2022). The Influence of Flipped Classroom-Based Project Assessment on Concept Understanding and Critical Thinking Skills in Physics Learning. Jurnal Pendidikan IPA Indonesia, 11(3), 351-362.

[36] Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14, 207–222.

[37] Gunawan, Harjono, A., Herayanti, L. & Husein, S. (2019). Problem-Based Learning Approach with Supported Interactive Multimedia in Physics Course: Its Effects on Critical Thinking Disposition. Journal for the Education of Gifted Young Scientists, 7(4), 1075-1089.

[38] Hasyim, F., Prastowo, T., & Jatmiko, B. (2020). The Use of Android-Based PhET Simulation as an Effort to Improve Students' Critical Thinking Skills during the Covid-19 Pandemic. International Journal of Interactive Mobile Technologies, 14(19), 31-41.

[39] Ismail, N. S., Harun, J., Zakaria, M. A. Z. M., & Salleh, S. M. (2018). The Effect of Mobile Problem-Based Learning Application DicScience PBL on Students' Critical Thinking. Thinking Skills & Creativity, 28(1), 177-195.

[40] Knudson, D. (2020): A tale of two instructional experiences: student engagement in active learning and emergency remote learning of biomechanics, Sports Biomechanics, 22, 1-11.

[41] Kozikoğlu, I. (2019). Investigating Critical Thinking in Prospective Teachers: Metacognitive Skills, Problem Solving Skills and Academic Self-Efficacy. Journal of Social Studies Education Research, 10(2), 111-130.

[42] Kuhn, D. (1999). A developmental model of critical thinking. Educational Researcher, 28(2), 16-46.

[43] Kurniawan, H. D. & Kuswanto, H. (2021). Improving Students' Mathematical Representation and Critical Thinking Abilities Using the CAKA Media Based on Local Wisdom. International Journal of Interactive Mobile Technologies, 15(2), 72-87.

[44] Kustyarini, K. (2020). Self Efficacy and Emotional Quotient in Mediating Active Learning Effect on Students' Learning Outcome. International Journal of Instruction, 13(2), 663-676.

[45] Les, T. & Moroz, J. (2021). More critical thinking in critical thinking concepts (?) A constructivist point of view. Journal for Critical Education Policy Studies (JCEPS), 19(1), 98-124.

[46] Lestari, T., Supardi, Z. A. I., & Jatmiko, B. (2021). Virtual Classroom Critical Thinking as an Alternative Teaching Model to Improve Students' Critical Thinking Skills in Pandemic Coronavirus Disease Era. European Journal of Educational Research, 10(4), 2003-2015.

[47] Machemer, P. L. & Crawford, P. (2007). Student perceptions of active learning in a large cross-disciplinary classroom. Active Learning in Higher Education, 8(1), 9– 30.

[48] Mafarja, N., Zulnaidi, H., & Fadzil, H. M. (2022). Using Reciprocal Teaching Strategy to Improve Physics Students' Critical Thinking Ability. EURASIA Journal of Mathematics, Science and Technology Education, 18(1), 1-14.

[49] Mahapatra, N., & Sahoo, J. (2022). Metrics employed in the evaluation of research productivity: A systematic literature review. Journal of Librarianship and Information Science, 0(0).

[50] Marnita, Taufiq, M., Iskandar, & Rahmi. (2020). The Effect of Blended Learning Problem-Based Instruction Model on Students' Critical Thinking Ability in Thermodynamic Course. Jurnal Pendidikan IPA Indonesia, 9(3), 430-438.

[51] Mulnix, J. W., & Mulnix, M. J. (2010). Using a writing portfolio project to teach critical thinking skills. Teaching Philosophy, 33(1), 27-54.

[52] Negoro, R. A., Rusilowati, A., & Aji, M. P. (2023). Scratch-Assisted Waves Teaching Materials: ICT Literacy and Students' Critical Thinking Skills. Journal of Turkish Science Education, 20(1), 189-210.

[53] Nisa, E. K., Jatmiko, B., & Koestiari, T. (2018). Development of Guided Inquiry-Based Physics Teaching Materials to Increase Critical Thinking Skills of Highschool Students. Jurnal Pendidikan Fisika Indonesia, 14(1), 18-25.

[54] Novitra, F., Festiyed, Yohandri, & Asrizal. (2021). Development of Online-based Inquiry Learning Model to Improve 21st-Century Skills of Physics Students in Senior High School. EURASIA Journal of Mathematics, Science and Technology Education, 17(9), 1-20.

[55] Oral, I. & Erkilic, M. (2022). Investigating the 21st-Century Skills of Undergraduate Students: Physics Success, Attitude, and Perception. Journal of Turkish Science Education, 19(1), 288-305.

[56] Parno, Fathurrahman, Asim, Suwasono, P., & Ali, M. (2019). The Influence of Problem Based Learning on Critical Thinking Ability for Students in Optical Instrument Topic. Jurnal Pendidikan Fisika Indonesia, 15(1), 39-45.

[57] Patrick, L. E., Howell, L. A., & Wischusen, W. (2016). Perceptions of active learning between faculty and undergraduates: Differing views among departments. Journal of STEM Education: Innovations and Research, 17(3), 55.

[58] Paul, R., & Elder, L. (2020). The miniature guide to critical thinking concepts and tools. USA: Rowman & Littlefield.

[59] Prince, M., & Felder, R. (2007). The many faces of inductive teaching and learning. Journal of College Science Teaching, 36(5), 14–20.

[60] Priyadi, A. & Kuswanto, H. (2023). The Android-Based Comic of Gajah Mungkur Dam: Improving Mathematical Representation and Critical Thinking Abilities. Journal of Technology and Science Education, 13(1), 116-129.

[61] Putra, P. D. A., Sulaeman, N. F., Supeno, & Wahyuni, S. (2023). Exploring Students' Critical Thinking Skills Using the Engineering Design Process in a Physics Classroom. Asia-Pacific Education Researcher, 32(1), 141-149.

[62] Putranta, H., Jumadi, & Wilujeng, I. (2019). Physics learning by PhET simulation-assisted using problem based learning (PBL) model to improve students' critical thinking skills in work and energy chapters in MAN 3 Sleman. Asia-Pacific Forum on Science Learning and Teaching, 30(1), 1-44.

[63] Rahayu, M. S. I. & Kuswanto, H. (2021). The Effectiveness of the use of the Android-Based Carom Games Comic Integrated to Discovery Learning in Improving Critical Thinking and Mathematical Representation Abilities. Journal of Technology and Science Education, 11(2), 270-283.

[64] Ren, P., Xiao, Y., Chang, X., Huang, P. Y., Li, Z., Gupta, B. B., Chen, X., & Wang, X. (2021). A Survey of Deep Active Learning. ACM Computing Surveys, 54(9), 1-40.

[65] Saputra, M. R. D. & Kuswanto, H. (2019). The Effectiveness of Physics Mobile Learning (PML) with HomboBatu Theme to Improve the Ability of Diagram Representation and Critical Thinking of Senior High School Students. International Journal of Instruction, 12(2), 471-490.

[66] Schmidt, S. K., Bratland-Sanda, S., & Bongaardt, R. (2022). Secondary school teachers' experiences with classroom-based physically active learning: "I'm excited, but it's really hard", Teaching and Teacher Education, 116, 103753.

[67] Sermeus, J., Cock, M. D., & Elen, J. (2021). Critical thinking in electricity and magnetism: assessing and stimulating secondary school students. International Journal of Science Education, 43(16), 2597-2617.

[68] Slisko, J. (2021). Facebook-supported tasks for exploring critical and creative thinking in a physics teaching course. Knowledge Management & E-Learning: An International Journal, 13(1), 58-82.

[69] Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. Journal of Engineering Education, 94(1), 87–101.

[70] Smith, T. E., Rama, P., & Helms, J. R. (2018). Teaching Critical Thinking in a GE Class: A Flipped Model. Thinking Skills & Creativity, 28(1), 73-83.

[71] Soysal, Y. (2020). Talking Science: Argument-Based Inquiry, Teachers' Talk Moves, and Students' Critical Thinking in the Classroom. Science & Education, 30(1), 33-65.

[72] Stump, G. S., Husman, J., & Corby, M. (2014). Engineering students' intelligence beliefs and learning. Journal of Engineering Education, 103(3), 369–387.

[73] Sujanem, R. & Suwindra, I. N. P. (2023). Problem-Based Interactive Physics E-Module in Physics Learning Through Blended PBL to Enhance Students' Critical Thinking Skills. Jurnal Pendidikan IPA Indonesia, 12(1), 135-145.

[74] Tiruneh, D. T., De Cock M., & Elen, J. (2018). Designing Learning Environments for Critical Thinking: Examining Effective Instructional Approaches, International Journal of Science and Mathematics Education, 16(6), 1065–1089.

[75] Valcanover, V. M., Sonza, I. B., & da Silva, W. V. (2020). Behavioral Finance Experiments: A Recent Systematic Literature Review. SAGE Open, 10(4), 1-16.

[76] Wakumire, R., Nkundabakura, P., Mollel, A. D., Nazziwa, C., & Wakhata, R. (2022). Impact of Project -based Learning on Students' Critical Thinking Skills in Kinematics in Mbale District, Uganda. East African Journal of Education and Social Sciences, 3(3), 160-170.

[77] Walsh, C., Lewandowski, H. J., & Holmes, N. G. (2022). Skills-focused lab instruction improves critical thinking skills and experimentation views for all students. Physical Review Physics Education Research, 18(1), 1-18.

[78] Walsh, C., Quinn, K.N., Wieman, C., & Holmes, N. G. (2019). Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking. Physical Review Physics Education Research, 15(1), 1-17.

[79] Wartono, Hudha, M. N., & Batlolona, J. R. (2018). How Are The Physics Critical Thinking Skills of The Students Taught by Using Inquiry-Discovery Through Empirical and Theorethical Overview?. EURASIA Journal of Mathematics, Science and Technology Education, 14(2), 691-697.

[80] Willingham, D.T. (2019). How to teach critical thinking. Department of Education and Training (NSW), 1–9.