JPPIPA 9(Special Issue) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Systematic Literature Review: Analysis of Student's Critical Thinking Skills towards Chemistry Learning

Hana' Fadhilah Retiyanto[1*], Sarmila Eka Putri[1], Muhammad Habib As-Shidiq[1], Suyanta[1]

[1] Departement of Chemistry Education Program, Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta, Yogyakarta

Received: October 19, 2023
Revised: November 29, 2023
Accepted: December 25, 2023
Published: December 31, 2023

Corresponding Author:
Hana' Fadhilah Retiyanto
hana0075fmipa.2022@student.uny.ac.id

DOI: 10.29303/jppipa.v9iSpecialIssue.6436

Abstract: The research was conducted with the aim of describing the literature review on students' thinking skills on chemistry learning. This research was conducted using the Systematic Literature Review (SLR) method. The articles used were sourced from the Scopus database assisted by Publish or Perish (PoP) with a range of years 2013-2023. The focus of this research is problems and solutions related to critical thinking skills, especially in chemistry learning. The results showed that students' difficulties in learning chemistry led to low students' critical thinking skills. Therefore, the right approach and learning model are needed in learning chemistry.

Keywords: Chemistry Learning; Critical Thinking Skills; Systematic Literature Review

Introduction

Education has an important role in human life. Education is expected to produce quality and resilient human resources so that they can compete in the era of globalization (Dewi and Riandi, 2015) in (Sari et al., 2018). The quality of education in Indonesia is still low (Sari et al., 2018). In the 21st century, the development of life is characterized as knowledge in the era of society which demands several skills that students have in order to compete in the global era (Rossana et al., 2019). Critical thinking skills are one of the 21st century skills needed. Critical thinking skills need to be trained to students and are expected to produce graduates with critical thinking skills as a provision for life in the future (Rossana et al., 2019). Skills include skills to communicate information, store, manage, analyze, create and access with the use of sophisticated technology (Wijaya et al., 2018).

Chemistry is one of the branches of science known as the central science that can connect other sciences. The principle of learning chemistry at school requires students to learn chemical concepts in a coherent, structured, and detailed manner.With that, students are required to understand chemical concepts well where not only memorizing theories, formulas, and chemical reactions. The purpose and function of learning chemistry is to direct a scientific attitude which includes a critical attitude towards scientific statements where it is not easy to believe if there is no support for observations, understanding of chemical concepts and their application in solving problems in everyday life. Therefore, in learning chemistry, training and developing critical thinking skills are important skills. In learning chemistry, students' critical thinking skills are low (Jufrina & Utami, 2016). The chemistry learning process must pay attention to students' thinking aspects. Operationalization of empowerment in learning on thinking empowerment is done through changing the learning paradigm from teacher centered to student centered (Prasetyowati & Suyatno, 2016). The impact of teacher-centered chemistry learning is that students' critical thinking is not trained, causing students' critical thinking skills to be low (Qurniati et al., 2015) in (Sari et al., 2018).

How to Cite:
Retiyanto, H.F., Putri, S.E., As-Shidiq, M.H., & Suyanta, S. (2023). Systematic Literature Review: Analysis of Student's Critical Thinking Skills towards Chemistry Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 113–121. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6436

In planning and implementing learning, teachers are expected to be able to train and develop students' thinking skills. The science process skills of children in Indonesia are low. The survey results from TIMSS (Third International Mathematics and Science Study) showed that the ability of Indonesian students in the field of science was ranked 38 out of 40 countries surveyed. While the results of the PISA (The Program for International Student Assessment) study stated that the ability of students in Indonesia in the field of science is still relatively low, due to the ability to remember scientific knowledge based on simple facts that are still new. One of the causes of low achievement in science is a science learning system that is more oriented to the content of science materials rather than oriented to science processes including chemistry (Prasetyowati & Suyatno, 2016).

Chemistry learning will be more meaningful if students are actively involved in learning (Sari et al., 2018). Chemistry material and critical thinking skills are inseparable because in understanding chemistry material through critical thinking skills. Likewise, the reverse critical thinking skills are trained with learning (Dewi, 2016) in (Sari et al., 2018). Chemistry learning in Indonesia should train students' thinking skills.The cause of low student thinking skills is the application of strategies in learning by teachers who have not been oriented towards empowering higher-order thinking and only emphasize understanding concepts (Prasetyowati & Suyatno, 2016). The result of the low critical thinking skills of students is that learning is still not connected to actual problems in everyday life. It is known that even though it is related to chemistry with scientific knowledge, it is found around in everyday life. In the formation of a better understanding of chemistry, chemical learning in schools should begin with solving problems that students often find in everyday life. According to Binadja cited by (Wijaya et al., 2018) chemistry learning in Indonesia focuses on pure science knowledge related to basic laws, theories and formulas to complete arithmetic operations. According to Forawi cited by (Wijaya et al., 2018) whereas in science learning students can be improved if directed to critical thinking through scientific experiments, data collection, deeper analysis, and integrating knowledge and processes.

Based on the explanation above, the problem that occurs is the problem of students' critical thinking skills in learning chemistry. This research aims to describe the literature review on students' thinking skills on chemistry learning. This research is very important to find out the problem of students' critical thinking skills in learning chemistry. The results of the study are expected to be able to provide information related to students' thinking skills in learning chemistry and are also expected to be able to make a reference in providing information related to students' critical thinking in learning chemistry.

Method

The method used in this research is Systematic Literature Review (SLR). The SLR method is a method for identifying, assessing, collecting and critically analyzing data from relevant research related to the topic under investigation (Snyder, 2019). SLR is a scientific method that strictly follows a series of steps to reduce the potential for systematic errors, by identifying, evaluating and combining all relevant studies, in order to answer a specific question or set of questions (Petticrew & Robberts, 2008). Activities include planning a search strategy for data and/or information sources, selecting studies based on quality assessment with eligibility criteria and quality assessment instruments, and data synthesis and data extraction.

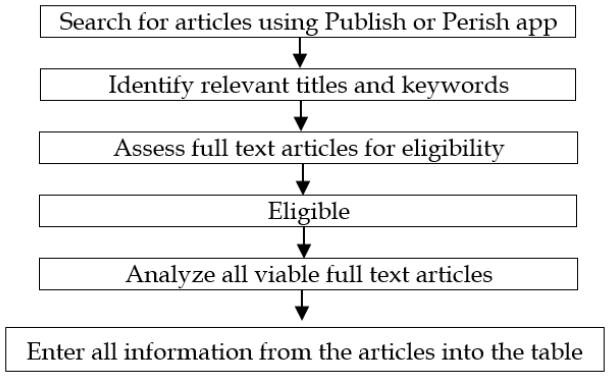

Figure 1. Research Method Flow Chart

In this research, the first step is to find sources of information. The sources of information used in this search are assisted using the Publish or Perish (PoP) application. The search carried out is a scopus indexed article. Searching based on the title word "Critical Thinking Skills Students" and the keyword "chemistry".

The next stage is the eligibility criteria. The eligibility criteria in this study used inclusion criteria. Inclusion criteria for article searches include: (1) articles on critical thinking skills in chemistry learning; (2) publication year range between 2013-2022; (3) publication in scopus indexed journals; (4) full text and open access; (5) publications are not in the form of seminar or conference papers. Systematic literature review using the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-analysis). The PRISMA method flowchart can be seen in figure 1 (Primadianningsih et al., 2023).

Based on the PRISMA method, a comprehensive search resulted in 200 scopus indexed articles from the title word "Critical Thinking Skills Students". Furthermore, based on the title word "Critical Thinking Skills Students" and the keyword "chemistry" resulted in

51 scopus indexed articles.After filtering the number of articles with a range starting from 2013 to 2023, 50 scopus indexed articles were found. Then proceed with the data synthesis stage.

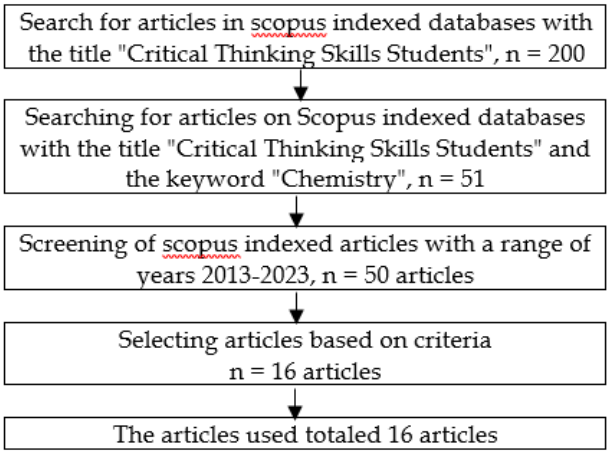

Figure 2. Article Screening Chart

The data synthesis process in this study was carried out by comparing literature that had met the quality assessment and inclusion and exclusion criteria. Data synthesis refers to the research objectives, namely mapping research topics on students' critical thinking skills in chemistry learning. The last stage is data extraction. The output of data extraction is a table consisting of the author's name, year of publication, research method, research objectives, and research results (Primadianningsih et al., 2023).

Result and Discussion

The results of the research data included in this literature review are articles related to students' critical thinking skills in chemistry learning presented in Table 1. Skills consist of core skills, soft skills, employability skills, key skills, generic skills and 21st century skills. Skills are essential in employment and include aspects such as written and oral communication, teamwork, problem solving, time management and critical thinking skills (Stephenson & Sadler-Mcknight, 2016).

Critical thinking skills are part of higher order thinking skills. According to Lia (2011) cited in (Suardana et al., 2018) revealed that critical thinking skills consist of skills to analyze arguments, make conclusions with inductive and deductive reasoning, assess or evaluate, and make decisions or solve problems. According to Halpern (1998) cited in (Stephenson & Sadler-Mcknight, 2016) revealed that critical thinking skills are very important skills for success in an increasingly dynamic and complex world.

Most universities and colleges, such as The University of the West Indies (UWI) revealed that critical thinking skills are required for graduates from these universities and colleges then most higher education revealed that the development of critical thinking skills as one of the main objectives in learning. Employers also identified critical thinking skills as important for graduates to enter the workforce (Stephenson & Sadler-Mcknight, 2016).

Research using standardized tests to measure critical thinking in chemistry using the Science Writing Heuristic (SWH) is still rare. Not only that, research proposed by Chaplin (2007) cited by (Stephenson & Sadler-Mcknight, 2016) shows that students who enter college who have poor critical thinking skills greatly affect their studies. Most human resources have low critical thinking skills (Suardana et al., 2018).

In the field of education, the problem is the lack of critical thinking skills. Several studies have shown that students' critical thinking skills are not fully developed due to a lack of focus on critical thinking by educators. Students are still included in the Beginner Thinker level on the critical thinking skills test (Everett et al., 2018; Ramos & Maed, 2018). Chemistry is a difficult subject for students. Chemistry learning guides are often monotonous and less relevant. Therefore, students cannot explore and develop their abilities, especially critical thinking skills (Khasanah & Azizah, 2018). Students' difficulties with linking chemistry concepts in everyday life lead to students' inability to explore and develop the skills needed, especially critical thinking. Students' poor critical thinking skills can be caused by failure to associate learning materials with real-world applications. Students are taught science concepts but without understanding the meaning of these knowledge concepts in their application in everyday life and cause loss of motivation (Purwanto et al., 2022).

Table 1. Article Data

Author's Name, Year	Method	Purpose	Findings
(Mutakinati et al., 2018)	Descriptive research	Knowing students' critical thinking skills by using STEM education through Project Based Learning	The results showed that the average score of students' critical thinking skills was 2.82. The category of students' critical thinking skills is practicing thinkers, which is a stage of critical thinking development in which they have enough skills to criticize their own plans for

Author's Name, Year	Method	Purpose	Findings
			systematic practice and to make realistic criticisms of their thinking ability to solve contextual problems.
(Purwanto et al., 2022)	Qualitative research	Developing students' critical thinking skills using a problem-oriented socio-critical approach in the study of nanoscience and nanotechnology (NST) materials.	This research shows that the socio-critical and problem-oriented approach in NST learning can positively contribute to the development of students' critical thinking skills. Students successfully applied their critical thinking skills in identifying, explaining, connecting, providing arguments, and concluding information related to social and scientific issues of NST.
(Ijirana et al., 2022)	Pre-Experimental Design One-Shot Case Study	Describe the critical thinking skills of chemistry education students who take STEM metacognitive skills lectures based on Team Project Based STEM.	The results of this study contribute to chemistry learning in the future, so that inevitably efforts are needed to train critical thinking skills for prospective chemistry teacher students in order to produce teachers who have good thinking skills.
(Ananda et al., 2022)	Qualitative research	Improving students' critical thinking skills by integrating Design Thinking with STEAM-PjBL in chemical redox learning.	The results showed that Design Thinking with STEAM-PjBL approach can develop critical thinking skills. Design Thinking is effective to facilitate students' learning, activating them creatively in creating project-based solutions. The integration of STEAM-PjBL approach and Design Thinking challenges students to connect chemistry concepts with real problems in daily life, providing a challenging and relevant learning experience. Therefore, the project was successful in developing students' critical thinking skills through a holistic and integrated approach.
(Weaver et al., 2016)		Encouraging mentoring relationships between each student and teaching assistant and encouraging students in project investment.	This research shows that the learning successfully provides students with an in-depth research experience, helps them develop relevant skills in the field of organic chemistry and demonstrates the effectiveness of the inquiry approach in upper-level chemistry learning.
(Danczak et al., 2020)	Mixed-methods	This study aims to develop and evaluate a chemistry-focused critical test, the DOT test, to measure the critical thinking skills of chemistry students.	The results showed that the final version of the DOT test had good internal reliability, strong test-retest reliability, moderate convergent validity compared to commercially available tests and was independent of academic achievement and previous university of study. Criterion validity testing showed that third-year students performed statistically better on the DOT test compared to first-year students, and graduate students and academics performed statistically better compared to third-year students. Statistical and qualitative analyses showed that the DOT test is a suitable instrument for use by the chemical education community to measure the development of critical thinking skills of undergraduate chemistry students.
(Astuti et al., 2020)	Research and Development	Develop and evaluate a 3D visualization program in virtual reality with the aim of improving critical thinking	The results showed that students who used 3D visualization had better results in critical thinking skills and scientific attitudes.

Author's Name, Year	Method	Purpose	Findings
		skills and scientific attitudes of high school students.	
(Oyewo et al., 2022)	Action research	This research aims to improve STEM students' critical thinking skills through project-based learning, particularly in the context of water management.	The results showed that project-based learning, specifically in water treatment activities using agricultural waste, was effective in improving STEM students' critical thinking skills.
(Stephenson et al., 2019)	Quasi-experimental research	The purpose of this study was to investigate the impact of implementing two active learning approaches, namely Peer-Led Team Learning (PLTL) and Science Writing and Workshop Template (SWWT), on the critical thinking skills of first-year chemistry students.	The results showed that the application of PLTL and SWWT learning strategies resulted in significantly higher improvements in critical thinking. Therefore, it can be concluded that PLTL and SWWT have a positive impact on the development of critical thinking skills of first-year chemistry students.
(Situmorang et al., 2022)	Mixed exploratory method	The aim of this study was to implement project-based learning to facilitate active and independent learning through project implementation to build students' critical thinking skills and at the same time facilitate students to achieve competencies in analytical chemistry needed by pharmaceutical and chemical scientists.	The results showed that students' critical thinking skills were very good. Project-based learning innovation is very effective in improving critical thinking skills and increasing student competence in analytical chemistry, especially in the context of the distillation process.
(Hakim et al., 2016)	Quasi-experimental research	This study aims to investigate the effect of mini-project practicum in natural chemistry on students' critical thinking skills.	This study shows that the mini practicum of natural chemistry project is better in improving students' critical thinking skills compared to the verification practicum.
(Febliza et al., 2023)	Comparative research with a quantitative approach	This study compared students' critical thinking skills through interactive media based on learning phenomena.	The results showed that the use of interactive web modules was more effective than interactive videos in improving students' critical thinking skills. This shows that the selection of appropriate instructional media, such as interactive web modules, can play an important role in improving students' critical thinking skills.
(Quattrucci, 2018)		This study aims to get students more involved in laboratory experiences and apply critical thinking skills to solve problems.	The results showed that a new method for teaching advanced laboratory at the undergraduate level provided positive results. Positive feedback from students indicated that this approach was successful in achieving the desired goals.
(Kawedhar et al., 2020)		This study aims to uncover how relevant shadow education is for developing students' 21st century skills, especially critical thinking skills.	The results showed that shadow education is still insignificant in responding to society's desire regarding students' critical thinking skills, especially in the context of 21st century skills. Nonetheless, the results showed that shadow education can help students with moderate cognitive abilities. Thus, although shadow education may not be a complete solution for developing 21st century skills, the

Author's Name, Year	Method	Purpose	Findings
			results show that shadow education can be an appropriate supplement to formal education, especially for those with moderate cognitive abilities.
(Purwanto et al., 2022)	Qualitative research	This study aims to develop students' critical thinking skills by integrating a socio-critical and problem-oriented approach to chemistry learning with environmental issues in Indonesia that students need to discuss.	The results of this study illustrate an increase in critical thinking skills, motivation, and student involvement in the learning process, thus supporting the use of a socio-critical and problem-oriented approach in chemistry learning.
(Suardana et al., 2018)	Experimental research	This study aims to describe the effectiveness of the local culture-based 7E learning cycle model in improving students' critical thinking skills in chemistry learning.	The results showed that the local culture-based 7E learning cycle model was more effective in improving students' critical thinking skills compared to the discovery learning model. Thus, it can be concluded that the application of the local culture-based 7E learning cycle model is effective in improving students' critical thinking skills in chemistry learning.

Indonesian students are still considered to have low critical thinking skills. Indonesian students' science scores are ranked 45th out of 50 countries in the Trends in International Mathematics and Science Study (2018) (Utomo et al., 2018). The results of TIMMS and PISA are requiring higher-order skills, such as critical thinking skills, students are expected to be able to make good inferences and provide causal explanations through several ways (OECD, 2016 cited by (Abdurrahman et al., 2019)). Experimental understanding of science alone is not enough to improve 21st century skills, but how to apply scientific concepts to design technology or products and solve problems is also needed.

Students are still expected to memorize formulas and answer questions correctly in chemistry class without being encouraged to think critically and creatively (Perdana & Wahyudin, 2022). Learning media is less effective, and understanding leads to memorization (Dewi et al., 2022). Students are less motivated to develop their thinking skills by using conventional media (Erna et al., 2021).

According to Norris and Ennis (1989) cited in (Stephenson & Sadler-Mcknight, 2016), suggested four instructional approaches that can be used in teaching critical thinking, including the general instruction approach, the infusion approach, the immersion approach and the blended approach. The blended approach involves explicit instruction in critical thinking combined with the application of skills in specific subject matter. According to Abrami, et al (2008) cited in (Stephenson & Sadler-Mcknight, 2016) revealed that the blended approach proved effective in helping students develop and hone critical thinking skills.

Schools need to teach critical thinking to help students ensure success in college and the workplace. Efforts for the development of critical thinking, such as writing, collaboration, inquiry and reflection are needed, and such skills need to be explicitly taught. Poor decision-making and problem-solving, misuse of resources, and lack of sustainable policy direction are all consequences of poor critical thinking. If universities are to produce graduates for the world of work who are critical thinkers, then initiatives that support the development of critical thinking skills at all levels of higher education are needed today. Science Writing Heuristic (SWH) is a solution to this problem. Research results also show that carefully designed interventions, such as SWH, can make the laboratory a potential platform for the development of critical thinking (Stephenson & Sadler-Mcknight, 2016).

In improving students' critical thinking skills, the learning model that can be done is 7E learning (Suardana et al., 2018). These phases include elicitation, engagement, exploration, explanation, elaboration, evaluation and extension. According to Eisenkraft (2003) cited by (Suardana et al., 2018) revealed that the learning model was developed from the 5E learning cycle model where previously there was no elicitation phase and extension phase.

The elicitation phase, identifying students' prior knowledge and ensuring students already know the subjects to be studied. This phase aims to determine students' readiness to learn and make students interested in chemistry subjects. The engagement phase, attracting students' attention or arousing students' interest in posing problems, telling stories, providing demonstrations, showing objects or images related to local culture as learning stimuli for students so that they learn actively. In the exploration phase, students are given the opportunity to observe, identify variables,

design investigations, interpret results, formulate hypotheses and make conclusions. In the explanation phase, students introduce and explain concepts and terms and then summarize the results found in the exploration phase. The elaboration phase, provides opportunities for students to apply new knowledge found or even conclusions to explain other cases, this phase can raise new problems in further investigations. Evaluation phase, students are given a formative evaluation of the development of students' knowledge of concepts, principles and ability to apply concepts. The extension phase, students are encouraged to connect and apply the concepts learned in everyday life (Suardana et al., 2018). According to Indriyani (2013) and Hartono (2013) cited by (Suardana et al., 2018) revealed that through the seven phases of 7E learning based on local culture, students can practice and develop students' critical thinking skills.

In addition to the 7E learning model, the socio-critical and problem-oriented approach adds value to chemistry learning in developing students' understanding of chemical concepts and students' awareness in problem-solving actions. This approach allows students to understand the material, realize that chemistry material is useful in everyday life and think critically in solving existing social problems through the knowledge or insight gained. The approach is in line with research conducted by (Purwanto et al., 2022) revealed that the application of a socio-critical and problem-oriented approach to environmental problems is able to improve students' critical thinking skills in acid-base learning. Some students have reached a good level of critical thinking skills with problem identification indicators considered to have experienced significant development as an initial ability in problem solving.

According to research conducted by Oz and Memis (2018) cited by (Abdurrahman et al., 2019) stated that the use of multi-modal representations in 'writing to learn' activities can improve students' scientific critical thinking skills. Students are able to form representations that are shown in their thinking by writing and using different modes including diagrams and images. To implement various representations through student worksheets in improving critical thinking skills on the theme of the role of energy in life. The results of research conducted by (Abdurrahman et al., 2019) show that students can be actively involved with multiple representation-based student worksheets in improving the learning performance of energy material. It can be concluded that multiple representation-based student worksheets are effective in improving students' critical thinking skills (Abdurrahman et al., 2019)

According to the Next Generation Science Standard (NGSS), critical thinking is identified as one of the most important skills. Some researchers have reported that students taught PjBL in the classroom improved their critical thinking and problem solving skills. Other researchers have also found that PjBL has become a successful method in 21st century skills (Mutakinati et al., 2018). Based on research conducted by (Hakim et al., 2016), the NP-MPL approach is significant in improving critical thinking skills compared to the verification laboratory method.

Contextual Learning (CL) is important to be integrated into chemistry learning to produce meaningful learning for students. CL encourages students to be able to connect academic content with real situations experienced by students. This is very important to help students retain information in the long term which will be useful for them to apply in real life (Davtyan, 2014).

Learning media can make it easier for teachers to explain lessons, and interesting media designs can make students think more critically (Erna et al., 2021; Kanmaz, 2022; Listiqowati et al., 2022). Using PhenoBL (Phenomenon-Based Learning) media is another way to help students improve their critical thinking skills. PhenoBL media is a learning media that uses phenomena as learning resources (Manowaluilou et al., 2022; Valanne et al., 2017; Wakil et al., 2019).

Conclusion

Critical thinking skills are one of the high-level skills. Critical thinking skills in chemistry learning are very important for students. There are problems in students' critical thinking skills, namely students' difficulties in learning chemistry causing low students' critical thinking skills. Therefore, the right strategy, approach and learning model are needed in learning chemistry. By applying the right learning approaches and models, it can increase students' thinking skills.

Acknowledgments
The authors would like to thank the co-authors who have assisted the authors in completing this systematic literature review article.

Author Contributions
Author contributions include Hana' Fadhilah Retiyanto, Sarmila Eka Putri, Muhammad Habib Ash Shiddiqi collected data, analyzed data, wrote the original draft; Suyanta focused on writing the review.

Funding
This study received no external funding.

Conflicts of Interest
The authors declare no conflict of interest

References

Abdurrahman, A., Setyaningsih, C. A., & Jalmo, T. (2019). Implementating multiple representation-based worksheet to develop critical thinking skills. *Journal of Turkish Science Education*, *16*(1), 138–155. https://doi.org/10.12973/tused.10271a

Ananda, L. R., Rahmawati, Y., & Khairi, F. (2022). Critical Thinking Skills of Chemistry Education Students in Team Project-based STEM-metacognitive Skills Learning during the COVID-19 Pandemic. *Journal of Technology and Science Education*, *4*(4), 352–367. https://doi.org/https://doi.org/10.3926/jotse.1938

Astuti, T. N., Sugiyarto, K. H., & Ikhsan, J. (2020). Effect of 3D visualization on students' critical thinking skills and scientific attitude in chemistry. *International Journal of Instruction*, *13*(1), 151–164. https://doi.org/10.29333/iji.2020.13110a

Danczak, S. M., Thompson, C. D., & Overton, T. L. (2020). Development and validation of an instrument to measure undergraduate chemistry students' critical thinking skills. *Chemistry Education Research and Practice*, *21*(1), 62–78. https://doi.org/10.1039/c8rp00130h

Dewi, C. A., Muhali, M., Kurniasih, Y., Lukitasari, D., & Sakban, A. (2022). The impact of Google Classroom to increase students' information literacy. *International Journal of Evaluation and Research in Education*, *11*(2), 1005–1014. https://doi.org/10.11591/ijere.v11i2.22237

Erna, M., Elfizar, & Dewi, C. A. (2021). The Development of E-Worksheet Using Kvisoft Flipbook Maker Software Based on Lesson Study to Improve Teacher's Critical Thinking Ability. *International Journal of Interactive Mobile Technologies*, *15*(1), 39–55. https://doi.org/10.3991/IJIM.V15I01.15679

Everett, A. C., Anderson, O. S., Wright, M. C., & Fontana, M. (2018). Longitudinal Assessment of Critical Thinking Skills Across a Dental Curriculum. *Journal of Dental Education*, *82*(9), 921–928. https://doi.org/10.21815/jde.018.088

Febliza, A., Afdal, Z., & Copriady, J. (2023). Improving Students' Critical Thinking Skills: Is Interactive Video and Interactive Web Module Beneficial? *International Journal of Interactive Mobile Technologies*, *17*(3), 70–86. https://doi.org/10.3991/ijim.v17i03.34699

Hakim, A., Liliasari, Kadarohman, A., & Syah, Y. M. (2016). Improvement of student critical thinking skills with the natural product mini project laboratory learning. *Indonesian Journal of Chemistry*, *16*(3), 322–328. https://doi.org/10.22146/ijc.21149

Ijirana, Aminah, S., Supriadi, & Magfirah. (2022). Critical Thinking Skills of Chemistry Education Students in Team Project-based STEM-metacognitive Skills Learning during the COVID-19 Pandemic. *Journal of Technology and Science Education*, *5*(3), 184–193. https://doi.org/https://doi.org/10.3926/jotse.1697

Jufrina, Y., & Utami, L. (2016). Pembelajaran Berbasis Masalah Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Pada Materi Reaksi Redoks. *JTK (Jurnal Tadris Kimiya)*, *1*(2), 58–63. https://doi.org/10.15575/jta.v1i2.1242

Kanmaz, A. (2022). Middle school teacher's critical thinking skills and awareness towards teaching critical thinking skills. *International Online Journal of Education and Teaching (IOJET)*, *9*(4), 1648–1671.

Kawedhar, M. C. S., Mulyani, S., Saputro, S., & Yamtinah, S. (2020). Shadow education in Indonesia: Is it relevant to students' critical thinking skills in chemistry learning? *International Journal of Learning, Teaching and Educational Research*, *19*(11), 223–241. https://doi.org/10.26803/ijlter.19.11.13

Khasanah, N., & Azizah, U. (2018). Train Students' Critical Thinking Skill Through the Implementation of Cooperative Learning Model Type Group Investigation (Gi) on Matter of Reaction Rate in Sma Negeri 1 Manyar. *Unesa Journal of Chemical Education*, *7*(1), 81–86. https://doi.org/https://doi.org/10.26740/ujced.v7n1.p%25p

Listiqowati, I., Budijanto, Sumarmi, & Ruja, I. N. (2022). The Impact of Project-Based Flipped Classroom (PjBFC) on Critical Thinking Skills. *International Journal of Instruction*, *15*(3), 853–868. https://doi.org/10.29333/iji.2022.15346a

Manowaluilou, N., Butkatunyoo, O., & Mahavijit, P. (2022). Phenomenon-based teaching competency development for teacher educators in higher education in Thailand. *Kasetsart Journal of Social Sciences*, *43*(3), 727–734. https://doi.org/10.34044/j.kjss.2022.43.3.26

Mutakinati, L., Anwari, I., & Yoshisuke, K. (2018). Analysis of students' critical thinking skill of middle school through stem education project-based learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54–65. https://doi.org/10.15294/jpii.v7i1.10495

Oyewo, O. A., Ramaila, S., & Mavuru, L. (2022). Harnessing Project-Based Learning to Enhance STEM Students' Critical Thinking Skills Using Water Treatment Activity. *Education Sciences*, *12*(11). https://doi.org/10.3390/educsci12110780

Perdana, R., & Wahyudin, Y. (2022). Inquiry Social Complexity-Based Chemistry Module to Empower Critical and Creative Thinking Skills. *Jurnal Pendidikan Progresif*, *12*(2), 777–784. https://doi.org/10.23960/jpp.v12.i2.202229

Petticrew, M., & Robberts, H. (2008). Systematic Reviews in the Social Sciences. *Systematic Reviews in the Social Sciences*, *42*(5), 1032–1034. https://doi.org/https://doi.org/10.1002/9780470754887

Prasetyowati, E. N., & Suyatno. (2016). Peningkatan Penguasaan Konsep Dan Keterampilan Berpikir Kritis Siswa Melalui Implementasi Model Pembelajaran Inkuiri Pada Materi Pokok Larutan Penyangga. *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, *1*(1), 67. https://doi.org/10.20961/jkpk.v1i1.10122

Primadianningsih, C., Sumarni, W., & Sudarmin, S. (2023). Systematic Literature Review: Analysis of Ethno-STEM and Student's Chemistry Literacy Profile in 21st Century. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 650–659. https://doi.org/10.29303/jppipa.v9i2.2559

Purwanto, A., Rahmawati, Y., & Rahmayanti, N. (2022). Socio-critical and problem-oriented approach in environmental issues for students ' critical thinking. *Journal of Technology and Science Education*, *12*(1), 50–67. https://doi.org/https://doi.org/10.3926/jotse.1341

Quattrucci, J. G. (2018). Problem-Based Approach to Teaching Advanced Chemistry Laboratories and Developing Students' Critical Thinking Skills. *Journal of Chemical Education*, *95*(2), 259–266. https://doi.org/10.1021/acs.jchemed.7b00558

Ramos, J.-J. R., & Maed. (2018). Critical Thinking Skills Among Senior High School Students and Its Effect in Their Academic Performance. *International Journal of Social Sciences & Humanities*, *3*(1), 60–72. http://ijssh.ielas.org/index.php/ijssh/article/view/69/pdf

Rossana, L., Siswandari, & Sudiyanto. (2019). Komik Digital Berbasis PBL Sebagai Upaya Peningkatan Motivasi dan Keterampilan Berpikir Kritis: Sebuah Kajian Literatur. *Seminar Nasional Pendidikan Pengembangan Kualitas Pembelajaran Era Generasi Milenial*, 28–35. http://hdl.handle.net/11617/10757

Sari, R. M. N., Suryaningsih, S., & Yunita, L. (2018). The Correlation of Guided Inquiry Model with SETS Approach on Students' Critical Thinking Skills. *Edusains*, *10*(2), 341–348. https://doi.org/10.15408/es.v10i2.10268

Situmorang, M., Sinaga, M., Sitorus, M., & Sudrajat, A. (2022). Implementation of Project-based Learning Innovation to Develop Students' Critical Thinking Skills as a Strategy to Achieve Analytical Chemistry Competencies. *Indian Journal of Pharmaceutical Education and Research*, *56*(1), S41–S51. https://doi.org/10.5530/ijper.56.1s.41

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*(August), 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Stephenson, N. S., Miller, I. R., & Sadler-Mcknight, N. P. (2019). Impact of Peer-Led Team Learning and the Science Writing and Workshop Template on the Critical Thinking Skills of First-Year Chemistry Students. *Journal of Chemical Education*, *96*(5), 841–849. https://doi.org/10.1021/acs.jchemed.8b00836

Stephenson, N. S., & Sadler-Mcknight, N. P. (2016). Developing critical thinking skills using the Science Writing Heuristic in the chemistry laboratory. *Chemistry Education Research and Practice*, *17*(1), 72–79. https://doi.org/10.1039/c5rp00102a

Suardana, I. N., Redhana, I. W., Sudiatmika, A. A. I. A. R., & Selamat, I. N. (2018). Students' Critical Thinking Skills in Chemistry Learning Using Local Culture-Based 7E Learning Cycle Model. *International Journal of Instruction*, *11*(2), 399. https://doi.org/https://doi.org/10.12973/iji.2018.11227a

Utomo, A. P., Narulita, E., Yuana, K., Fikri, K., & Wahono, B. (2018). Students' errors in solving science reasoning-domain of trends in international mathematics and science study (TIMSS). *Jurnal Pendidikan IPA Indonesia*, *7*(1), 48–53. https://doi.org/10.15294/jpii.v7i1.11352

Valanne, E., Dhaheri, R. Al, Kylmalahti, R., & Sandholm-Rangell, H. (2017). Phenomenon Based Learning Implemented in Abu Dhabi School Model. *International Journal of Humanities and Social Sciences*, *9*(3), 1–17. http://ijhss.net/index.php/ijhss

Wakil, K., Rahman, R., Hasan, D., Mahmood, P., & Jalal, T. (2019). Phenomenon-Based Learning for Teaching ICT Subject through other Subjects in Primary Schools. *Journal of Computer and Education Research*, *7*(13), 205–212. https://doi.org/10.18009/jcer.553507

Weaver, M. G., Samoshin, A. V., Lewis, R. B., & Gainer, M. J. (2016). Developing Students' Critical Thinking, Problem Solving, and Analysis Skills in an Inquiry-Based Synthetic Organic Laboratory Course. *Journal of Chemical Education*, *93*(5), 847–851. https://doi.org/10.1021/acs.jchemed.5b00678

Wijaya, W. S., Feronika, T., & Fairusi, D. (2018). Penerapan Problem Based Learning Berpendekatan Sets Terhadap Keterampilan Berpikir Kritis Siswa. *JTK (Jurnal Tadris Kimiya)*, *3*(1), 94–103. https://doi.org/10.15575/jtk.v3i1.2338