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STEM-CTL: An Initiative to Promote Elementary School Students' Critical Thinking Skills

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ABSTRACT

The present study employed a quasi-experimental, one-group pretest-posttest design to examine the effectiveness of the STEM-CTL model in promoting critical thinking among elementary school students. The study sample consisted of 34 students from 4th grade at an elementary school. They were selected using the non-probability sampling technique. The independent research variable was STEM-CTL, while the dependent variables consisted of critical thinking aspects, including the ability to formulate a problem, the ability to give arguments, the ability to make deductions and inductions, and the ability to draw inferences. Data on participants' critical thinking were collected using a test and analyzed using descriptive and inferential statistics (paired sample t-test). The analysis results revealed a significant effect of STEM-CTL on participants' critical thinking skills (at a significance level of 0.000 > 0.05). Hence, H0 was rejected, and Ha was accepted. The N-gain score was medium (0.63), indicating that STEM-CTL effectively promoted critical thinking skills among elementary school students.

Keywords
Critical Thinking Skills
Contextual Teaching and Learning
Elementary School
STEM

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Introduction

In the 21st century, competition in the education sector is becoming increasingly fierce, especially in providing a learning system capable of producing graduates who can integrate knowledge and skills. Apart from that, 21st century education also challenges today's educators to create competitive and adaptive students. One of the skills students need to contribute to 21st-century society is critical thinking. Critical thinking means reflecting deeply on problems, maintaining an open mind to various different approaches and perspectives, and not blindly trusting information from various sources (oral or written) [1]. Critical thinking is reflective thinking rather than just accepting ideas from outside without significant understanding and evaluation [2]. Critical thinking is a way of thinking about analyzing an argument that leads to insights [3]. Critical thinking means understanding and interpreting problems, which allows someone to solve problems and create alternative solutions to problems [4].

The stimuli provided by teachers influence students' thinking skills, thus necessitating the implementation of learning activities that foster critical thinking processes [5], [6]. Active learning processes have been shown to be effective in cultivating students' critical thinking [7]. Therefore, schools have a responsibility to facilitate the development of essential skills and values, including creativity, critical thinking, and problem-solving [8], [9]. However, despite the adoption of the 2013 Curriculum, the learning process continues to be teacher-centered, with limited student engagement in learning activities. Consequently, students' critical thinking skills remain underdeveloped and unevenly distributed. To address this challenge, teachers can employ instructional models that facilitate students' identification of key concepts, thereby enhancing the meaningfulness of the learning experience.

The active learning approach facilitates the connection between instructional content and students' real-world experiences, hence enhancing the meaningfulness of the learning process for students [10]. Meaningful learning enhances the acquisition, mastery, and cognitive processing of instructional content by pupils. Numerous learning models have been examined in prior scholarly investigations. The implementation of project-based learning in the context of ethno-STEM has been found to have a notable impact on enhancing students' capacities for critical and creative thinking [11]. Problem Based Learning using STEM (PBL-STEM), which is supported by virtual-simulation media, has a significant influence on students' critical thinking skills [12]. STEM problem-based learning modules have been proposed as a potential remedy for addressing the limited problem-solving skills exhibited by elementary school children [13]. The integration of STEM-PjBL has been found to have a notable impact on the development of higher-order thinking skills [14]. The integration of B-Netra media into STEM has the potential to enhance scientific literacy among pupils [15]. Contextual teaching and learning (CTL) can

promote critical thinking skills [16] by incorporating various adaptations, including the utilization of e-modules [17], audiovisual media [18], and games [19]. The various successes of STEM and CTL give confidence that the combination of the two can potentially support students' critical thinking skills.

STEM is an interdisciplinary field that encompasses science, engineering, mathematics, and technology. It involves the application of scientific principles, the design and implementation of engineering solutions, the utilization of mathematical reasoning and logic, and the incorporation of technological advancements to address real-world problems [20]. The implementation of a STEM-based educational approach is capable of establishing a unified and dynamic system, as all four components must be concurrently engaged in order to effectively address everyday challenges [21]. In the context of CTL, the process of learning involves the activation of pre-existing information. This implies that the acquisition of new knowledge is inherently connected to the knowledge that already exists within an individual. Consequently, students are able to develop a comprehensive and interconnected understanding of the subject matter [22]. CTL provides students with the opportunity to establish connections between academic information and the broader context of everyday life, facilitating the discovery of meaning. CTL also offers students the chance to enhance their knowledge through the provision of novel experiences that facilitate cognitive connections and the discovery of new insights.

The integration of issues relevant to students' lives into learning models has the potential to facilitate the identification of critical thinking lessons. However, the implementation of learning models designed to enhance students' critical thinking skills has not been widely adopted within the classroom setting. STEM-CTL is a novel educational approach that actively engages students in the process of knowledge acquisition and its application to real-world contexts. The integration of contextual learning (CTL) with science, technology, engineering, and mathematics (STEM) elements affords pupils the chance to acquire comprehensive knowledge. The integration of STEM-CTL in education can enhance students' proficiency in addressing practical challenges across many scientific domains, hence fostering the cultivation of critical thinking skills.

Material and Methods

The present study used a quasi-experimental research approach due to the difficulty in manipulating research variables [23]. A one-group pretest-posttest design was employed, wherein the experiment was conducted just on a single group without the inclusion of a comparison group. The execution of this study involved the division of activities into three distinct series. Prior to undergoing treatment (X), participants were administered a pretest to

assess their initial critical thinking skills. Subsequently, the participants were subjected to a study intervention (X), namely engaging in two STEM-CTL learning sessions. Following their engagement in STEM-CTL instruction, students proceeded to do a post-test. The post-test outcomes were utilized to compute the N-gain score, which represents the disparity in the critical thinking skills of the individuals before and after receiving the research intervention [24].

The research sample was obtained using the non-probability sampling technique. A total of 34 fourth-grade pupils were included in the study as members of the same group. The research under consideration focused on the STEM-CTL learning model as the independent variable. The dependent variables of the study consisted of aspects of critical thinking, including the ability to formulate a problem, the ability to give arguments, the ability to make deductions and inductions, and the ability to draw inferences. The data were gathered using a test and subsequently subjected to analysis employing both descriptive and inferential statistical methods, specifically utilizing the paired sample t-test procedure.

The instrument used to measure participants' critical thinking skills consisted of 12 essay questions. The test had been validated by two experts in learning and underwent the Pearson's correlation test which resulted in 10 valid and 2 invalid items of the test (compared to the r_{table} of 0.32). The test' reliability was calculated using Cronbach's Alpha, resulting in a Cronbach's Alpha value of 0.667 (fairly reliable).

The critical thinking data collected before and after the research intervention were analyzed using descriptive statistics (using categorization as poor, medium, and high). Then, assumption tests, including tests of normality and homogeneity, were conducted prior to hypothesis testing. The research hypothesis was examined using the paired sample t-test. The paired sample t-test was done to investigate the difference in participants' mean scores and to determine the N-Gain score.

Results

The examination of data pertaining to critical thinking skills (CTS) acquired from the pretest revealed a prevailing tendency among students for their CTS to be at a low level. One student obtained a high score on the CTS assessment, representing 3% of the total sample. Additionally, three students achieved a medium score on the CTS, accounting for 8.8% of the sample. Most students, namely 30 individuals, obtained a poor score on the CTS, constituting 88.2% of the sample. Following the participation in two STEM-CTL learning sessions, each lasting around 70 minutes, there was an observable enhancement in students' level of engagement, leading to a discernible improvement in their critical thinking skills. In this research, the CTS aspects measured refer to the ability to formulate a problem, the ability to give arguments, the ability to make deductions and inductions, and the ability to draw

inferences [25]–[28]. Table 1 displays the relationship between the stages in STEM-CTL [29], [30] and the CTS indicators assessed in the present study.

Table 1. The Relationship Between the Stages in STEM-CTL and the CTS Indicators

Stages in STEM-CTL	Activities in STEM-CTL	Indicators of CTS
Constructivism	At this stage, students are encouraged to make observations of various phenomena or issues found in the daily life environment that are related to the lesson.	The ability to formulate a problem
Inquiry	At this stage, students observe and look for additional information about phenomena or issues related to the topic being discussed. Then, they are asked to design new ideas from existing information.	The ability to make deductions and inductions.
Questioning	This stage cultivates students' critical thinking by posing questions that deepen their understanding of concepts. The discovery is combined with existing knowledge to solve problems. Individual and group problem-solving strategies are presented by students.	The ability to give arguments, the ability to make deductions and inductions
Learning Community	At this stage, the teacher explains to students the rules of group work and the division of group work. At this stage, the teacher takes a significant role in guiding student discussions and determining whether students have developed a conceptual and relevant understanding based on the problem.	The ability to give arguments
Modelling	At this stage, the teacher demonstrates how to perform and behave properly. Students learn a broader context by integrating their problem-solving with STEM during the problem-solving phase.	The ability to give arguments, the ability to make deductions
Reflection	Students test the knowledge they have gained through reflection questions. At this stage, students communicate solutions to friends and the class. Presentations develop communication and collaboration skills as well as the ability to receive and apply constructive feedback.	The ability to draw inferences
Authentic Assessment	The teacher assesses the critical thinking aspects that have been achieved during the lesson. The teacher evaluates the solutions proposed by students based on STEM elements.	The ability to draw inferences

The implementation of STEM-CTL resulted in a notable improvement in critical thinking scores, as seen by the increase in the percentage of scores categorized as high, compared to the initial categorization of poor. The results of the post-test indicated that none of the students exhibited poor cognitive thinking skills (CTS), while 8.8% displayed moderate CTS, and the majority, 91.2%, demonstrated high CTS. To ascertain the statistical significance of the impact of STEM-CTL on students' CTS, a hypothesis test was conducted. The selection of analytical technique for hypothesis testing was predicated upon the results of assumption tests, namely tests normality and homogeneity.

A. Test of Normality

The normality test was used in the experimental class using data obtained from the pre-test and post-test. The provisions of the normality test were that if the significance obtained was > 0.05 then it had a normal distribution, but if the significance obtained was < 0.05, then

the data would have an abnormal distribution [31]. Table 2 shows the results of the Kolmogorov-Smirnov normality test.

Table 2. The Normality Test

		PRE-TEST	POST TEST
N		34	34
Normal Parameters[a,b]	Mean	53.09	82.65
	Std. Deviation	8.901	5.898
Most Extreme Differences	Absolute	.129	.150
	Positive	.063	.106
	Negative	-.129	-.150
Test Statistic		.129	.150
Asymp. Sig. (2-tailed)		**.164[c]**	**.052[c]**

According to Tabel 2, the significance value for the pretest data normality was 0.164 > 0.05, while for the post-test data was 0.052 > 0.05. Hence, it was concluded that the pretest and post-test data were distributed normally.

B. Test of Homogeneity

The homogeneity test was used in the experimental class using data obtained from the pre-test and post-test. The provisions of the normality test were that if the significance obtained was > 0.05 then it had a homogeneous variance, but if the significance obtained was < 0.05 then the data did not have a homogeneous variance [31]. Table 3 displays the results of *Levene's Statistic* test.

Table 3. The Homogeneity Test

Levene Statistic	df1	df2	Sig.
3.570	1	66	**.063**

According to Table 3, the significance value for data homogeneity was 0.063 (> 0.05). Therefore, it was concluded that the data had a homogeneous variance. Since the results of the assumption tests showed that the data were distributed normally and a homogeneous variance, the hypothesis testing was conducted using parametric statistics.

C. Hypothesis Testing

Hypothesis testing was performed to examine the effect of STEM-CTL on participants' CTS. Ho was rejected if the significance level was < 0.05 and accepted if the significance level was > 0.05 [32], [33]. The results of the paired sample t-test to examine the research hypothesis can be seen in Table 4.

Tabel 4 shows a significance level of 0.00 < 0.05, indicating a significant difference in participants' critical thinking scores before and after the administration of research intervention. After that, we calculated the N-Gain score to determine the effectiveness of STEM-CL in improving elementary school students' critical thinking skills.

Table 4. Hypothesis Testing with the Paired Sample T-Test

	Paired Difference					t	Df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair1 PRE TEST-POST TEST	-29.559	5.679	.974	-31.540	-27.577	-30.348	33	.000

The N-Gain score was calculated using the pretest mean score (53.08), the post-test mean score (82.65), and the maximum score of 100 [34]

$$g = \frac{82.65-53.08}{100-53.08} \quad (1)$$

$$g = \frac{29.57}{46.92} = 0.63 \quad (2)$$

The gain index of 0.63 indicated that the participants experienced a corresponding rise of 0.63 in their critical thinking skills, which was classified as moderate. In addition, the hypothesis testing results showed a significance level smaller than 0.05 (0.00). These findings indicated that STEM-CL influenced participants' critical thinking skills. The N-Gain score of 0.63 provided additional evidence supporting the moderate efficiency of STEM-CL in enhancing participants' critical thinking skills.

Discussion

The findings of the current study align with Ref. [35], indicating that the utilization of the STEM method has the potential to increase students' critical thinking skills (CTS). A previous study further mentioned that the experimental group had a notable N-gain of 0.63, whereas the control group exhibited a comparatively lower N-gain of 0.35. Students' critical thinking skills can be achieved by implementing STEM, since the utilization of a STEM-oriented pedagogical approach effectively fosters student engagement in the learning process, empowering them to independently seek solutions to real-world problems. Engagement in problem-solving activities has been found to have a positive impact on the development of students' critical thinking skills [36]. Research has also demonstrated that several learning models, such as STEM [38], CTL [39], and STEM-PBL [40] can impact the development of students' critical thinking skills.

According to research findings, students that engage in STEM (science, technology, engineering, and mathematics) education tend to exhibit enhanced cognitive learning outcomes. This can be attributed to their ability to effectively analyze, evaluate, and assess complex problems, as well as their aptitude for innovation [41]. CTL encourages students to express their opinions in groups in order to train them to provide learning-related arguments [42]. According to the current study, students showed the greatest increase in the ability to draw conclusions or inferences.

Contextual teaching and learning (CTL) refers to the pedagogical approach that involves the utilization of pre-existing knowledge, whereby students establish connections between their earlier experiences. Furthermore, the implementation of Contextual Teaching and Learning (CTL) has the potential to enhance students' comprehension of concepts. This is attributed to the fact that students can independently explore and grasp these concepts by actively applying their acquired knowledge within the framework of real-life situations. Knowledge application holds the potential to promote critical thinking [44]. The findings of the present study also demonstrated a notable shift in the behavior of students who had previously exhibited passivity in their engagement with the learning process, as they had a greater inclination towards active participation. CTL encourages students to get actively involved in searching and solving problems to discover new knowledge. CTL, as a student-centered learning model, trains students' problem-solving and critical thinking skills. In another study, the CTL model was effective and practical in sharpening students' critical thinking (cognitive) skills and environmental awareness [45].

In addition to CTL, students find STEM-based learning applications to be very engaging due to the integration of four distinct domains of science, namely knowledge, technology, engineering, and mathematics. The combination of these four facets is a complementary match between the occurrence of problems and the real world [21]. One of the benefits associated with STEM in the classroom is the enhancement of students' creative and critical thinking abilities, thereby fostering increased self-assurance among them [46].

The utilization of the STEM method in support of CTL can enhance students' cognitive abilities. STEM-CTL involves the establishment of a scientific milieu that entails fostering a learning environment wherein students actively engage in experiential learning, hence enhancing the meaningfulness of their educational experiences. Rather than only acquiring knowledge, students are encouraged to actively participate in hands-on activities that enable them to directly apply and experience the concepts being taught. Subsequently, students possess the ability to establish connections between the subject matter and their everyday experiences, thereby potentially fostering intrinsic motivation to comprehend the content rather than merely memorizing it. The STEM-CTL model necessitates student engagement in the learning process due to the multifaceted nature of the interactions involved. This approach allows students the autonomy to voice their perspectives based on their individual thoughts while still adhering to the core content being studied. Building a situation like this makes learning take place naturally and fosters effective communication.

The enhancement of students' critical thinking skills is intricately linked to the role of instructors in maximizing the effectiveness of the STEM-CTL model within the educational setting. Teachers must consider the compatibility of learning activities with the model's stages

in order to make learning more meaningful. Engaging in learning activities that align with the stages of the learning model has been found to have a significant impact on the development of students' critical thinking skills [47]. Observation sheets were utilized to quantify the implementation of each STEM-CTL stage. Observations of STEM-CTL implementation at the first meeting revealed that 88.3% of STEM-CTL stages were implemented, while at the second meeting, 91.7% of STEM-CTL stages were implemented effectively. Therefore, it can be concluded that the educator has implemented learning activities in accordance with the stages in STEM-CTL.

The present study has shown that the implementation of STEM-CTL in the classroom has a positive effect on the critical thinking skills of students. Because students took an active role during the learning process, they could develop their critical thinking skills when solving problems related to the presented themes. Students in this study could comprehend, analyze, synthesize, and evaluate a problem to find a solution, allowing them to derive conclusions from its resolution. The findings derived from this process contribute to the generation of novel knowledge, which is directly linked to the content that students generate independently, rather than solely relying on information acquired from the teacher through traditional learning methods.

Conclusion

According to the results of the data analysis and discussion, STEM-CTL (Science, Technology, Engineering and Mathematic – Contextual Teaching Learning) was effective in enhancing students' critical thinking skills with a moderate N-Gain score (0.63 or 63%). The hypothesis testing showed a significance value of $0.000 < 0.05$, which suggested to reject H_o and accept H_a. The hypothesis testing results indicated that there was a difference in participants' critical thinking skills before and after receiving the research intervention (STEM-CTL). Given the favorable outcomes observed in the implementation of the STEM-CTL learning framework, it would be advantageous for educators to incorporate this pedagogical approach into instructional practices to enhance students' critical thinking skills.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

[1] V. Erdoğan, "Integrating 4C Skills of 21st Century into 4 Language Skills in EFL Classes," *Int. J. Educ. Res.* , vol. 7, no. 11, pp. 113–127, 2019, [Online]. Available: www.ijern.com

[2] M. J. Bezanilla, D. Fernández-Nogueira, M. Poblete, and H. Galindo-Domínguez, "Methodologies for teaching-learning critical thinking in higher education: The teacher's view," *Think. Ski. Creat.*, vol. 33, p. 100584, 2019, doi: https://doi.org/10.1016/j.tsc.2019.100584.

[3] S. A. Seibert, "Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance," *Teach. Learn. Nurs.*, vol. 16, no. 1, pp. 85–88, 2021, doi: https://doi.org/10.1016/j.teln.2020.09.002.
[4] N. J. Alsaleh, "Teaching Critical Thinking Skills : Literature Review," *Turkish Online J. Educ. Technol.*, vol. 19, no. 1, pp. 21–39, 2020.
[5] F. Fauzi, M. Erna, and R. Linda, "The Effectiveness of Collaborative Learning Throughtechniques on Group Investigation and Think Pair Share Students' Critical Thinking Ability on Chemical Equilibrium Material," *J. Educ. Sci.*, vol. 5, no. 1, p. 198, 2021, doi: 10.31258/jes.5.1.p.198-208.
[6] A. Kosasih, T. Supriyadi, M. I. Firmansyah, and N. Rahminawati, "Higher-Order Thinking Skills in Primary School," *J. Ethn. Cult. Stud.*, vol. 9, no. 1, pp. 56–76, Sep. 2022, [Online]. Available: https://www.jstor.org/stable/48710289
[7] F. Zamora-Polo, M. Corrales-Serrano, J. Sánchez-Martín, and L. Espejo-Antúnez, "Nonscientific University Students Training in General Science Using an Active-Learning Merged Pedagogy: Gamification in a Flipped Classroom," *Education Sciences*, vol. 9, no. 4. 2019. doi: 10.3390/educsci9040297.
[8] T. Tang, V. Vezzani, and V. Eriksson, "Developing critical thinking, collective creativity skills and problem solving through playful design jams," *Think. Ski. Creat.*, vol. 37, p. 100696, 2020, doi: https://doi.org/10.1016/j.tsc.2020.100696.
[9] P. Kwangmuang, S. Jarutkamolpong, W. Sangboonraung, and S. Daungtod, "The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools," *Heliyon*, vol. 7, no. 6, p. e07309, 2021, doi: 10.1016/j.heliyon.2021.e07309.
[10] T. I. B. Al-Tabany, *Mendesain Model Pembelajaran Inovatif, Progresif dan Kontekstual Konsep Landasan dan Implementasinya pada Kurikulum 2013 (Kurikulum Tematik Integratif/KTI)*. Jakarta: Kencana, 2017.
[11] W. Sumarni and S. Kadarwati, "Ethno-stem project-based learning: Its impact to critical and creative thinking skills," *J. Pendidik. IPA Indones.*, vol. 9, no. 1, pp. 11–21, 2020, doi: 10.15294/jpii.v9i1.21754.
[12] Parno *et al.*, "The increase of students' critical thinking abilities on optical instrument topic through pbl-stem with virtual simulation media," *J. Phys. Conf. Ser.*, vol. 1918, no. 5, p. 52067, 2021, doi: 10.1088/1742-6596/1918/5/052067.
[13] S. T. Martaningsih *et al.*, "STEM problem-based learning module: a solution to overcome elementary students' poor problem-solving skills," *Pegem J. Educ. Instr.*, vol. 12, no. 4, pp. 340–348, Oct. 2022, doi: 10.47750/PEGEGOG.12.04.35.
[14] I. Maryani *et al.*, "The Effect of The STEM-PjBL Model on The Higher-Order Thinking Skills of Elementary School Students," *Sekol. Dasar Kaji. Teor. dan Prakt. Pendidik.*, vol. 30, no. 2, pp. 110–122, Nov. 2021, doi: 10.17977/UM009V30I22021P110.
[15] G. Aditya and I. Maryani, "STEM Based B-Netra as a Media to Foster Scientific Literacy of Students with Visual Impairment," *AIP Conf. Proc.*, vol. 2600, no. 1, Dec. 2022, doi: 10.1063/5.0131835/2830601.
[16] S. Sudarmiani, "The Development of Economic Learning Model through CTL (Contextual Teaching and Learning) to Promote Students' Critical Thinking Skill," *Budapest Int. Res. Critics Linguist. Educ. J.*, vol. 3, no. 2, pp. 714–723, 2020, doi: 10.33258/birle.v3i2.900.
[17] N. Amrilizia, H. Habiddin, and M. F. Marsuki, "Improving Students' Critical Thinking Skills Using e-Modules-Contextual Teaching and Learning (CTL) on the Interaction of Living Organisms with Their Environment," *J. Disruptive Learn. Innov.*, vol. 3, no. 2, pp. 65–82, 2022, [Online]. Available: http://dx.doi.org/10.17977/um072v3i22022p%25p
[18] K. Sarwinda, E. Rohaeti, and M. Fatharani, "The development of audio-visual media with contextual teaching learning approach to improve learning motivation and critical thinking skills," *Psychol. Eval. Technol. Educ. Res.*, vol. 2, no. 2, p. 98, 2020, doi: 10.33292/petier.v2i2.12.
[19] C.-Y. Chang, C.-H. Kao, G.-J. Hwang, and F.-H. Lin, "From experiencing to critical thinking: a contextual game-based learning approach to improving nursing students' performance in Electrocardiogram training," *Educ. Technol. Res. Dev.*, vol. 68, no. 3, pp. 1225–1245, 2020, doi: 10.1007/s11423-019-09723-x.
[20] Yuanita and F. Kurnia, "Analisis STEM (Science, Technology, Engenering, and Mathematicss) Materi Kelistrikan Pada Buku Tematik Tema 3 Kelas 6 Sekolah Dasar," *STKIP Muhammadiyah Bangka Belitung*, 2019.
[21] R. Widya Sukmana, "Pendekatan Science, Technology, Engineering And Mathematics (STEM) Sebagai Alternatif Dalam Mengembangkan Minat Belajar Peserta Didik Sekolah Dasar," *Pendas J. Ilm. Pendidik. Dasar*, vol. 2, no. 2, p. 189, Mar. 2018, doi: 10.23969/jp.v2i2.798.

[22] W. Sanjaya, *Strategi Pembelajaran Berorientasi Standar Proses Pendekatan*. Jakarta: Prenada Media Group, 2016.
[23] Sudaryono, *Metode Penelitian Pendidikan*. Jakarta: Kencana, 2016.
[24] Sugiyono, *Statistika untuk Penelitian*. Bandung: Alfabeta, 2017.
[25] R. Zulmaulida, Wahyudin, and J. A. Dahlan, "Watson-Glaser's Critical Thinking Skills," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, p. 12094, 2018, doi: 10.1088/1742-6596/1028/1/012094.
[26] A. Masek and S. Yamin, "The Effect of Problem Based Learning on Critical Thinking Ability: A Theoretical and Empirical Review," *Int. Rev. Soc. Sci. Humanit.*, vol. 2, no. 1, pp. 215–221, 2011, [Online]. Available: www.irssh.com
[27] J. Heard, C. Scoular, D. Duckworth, D. Ramalingam, and I. Teo, "Critical Thinking : Skill Development Framework.," *Aust. Counc. Educ. Res.*, pp. 1–23, 2020.
[28] Y. Bustami and A. D. Corebima, "The Effect of Jirqa Learning Strategy on Critical Thinking Skills of Multiethnic Students in Higher Education, Indonesia," *Int. J. Humanit. Soc. Sci. Educ.*, vol. 4, no. 3, pp. 13–22, 2017, doi: 10.20431/2349-0381.0403003.
[29] D. T. Wahyuningtyas, "the Assembling of Contextual Teaching and Learning (Ctl) Model Assisted By Origami Paper Media for Increasing Plane Learning Result in the Fifth Grade of Primary School," *Int. J. Elem. Educ.*, vol. 1, no. 3, p. 176, 2017, doi: 10.23887/ijee.v1i3.11766.
[30] D. K. Tari and D. Rosana, "Contextual Teaching and Learning to Develop Critical Thinking and Practical Skills," *J. Phys. Conf. Ser.*, vol. 1233, no. 1, p. 12102, 2019, doi: 10.1088/1742-6596/1233/1/012102.
[31] T. K. Kim and J. H. Park, "More about the basic assumptions of t-test: normality and sample size," *Korean J Anesth.*, vol. 72, no. 4, pp. 331–335, Apr. 2019, doi: 10.4097/kja.d.18.00292.
[32] L. R. Sharma and S. Jha, "Applying Major Parametric Tests Using SPSS in Research," *Int. Res. J. MMC*, vol. 4, no. 2, pp. 85–97, Jun. 2023, doi: 10.3126/IRJMMC.V4I2.56017.
[33] D. Howitt and D. Cramer, *Understanding statistics in psychology with SPSS*. Pearson, 2020. Accessed: Oct. 01, 2023. [Online]. Available: https://thuvienso.hoasen.edu.vn/handle/123456789/12855
[34] R. Sundayana, *Statistika Penelitian Pendidikan*. Bandung: Alfabeta, 2014.
[35] N. Khoiriyah, A. Abdurrahman, and I. Wahyudi, "Implementasi pendekatan pembelajaran STEM untuk meningkatkan kemampuan berpikir kritis siswa SMA pada materi gelombang bunyi," *J. Ris. dan Kaji. Pendidik. Fis.*, vol. 5, no. 2, p. 53, 2018, doi: 10.12928/jrkpf.v5i2.9977.
[36] A. Yasifa, N. H. Hasibuan, P. A. Siregar, S. Zakiyah, and N. Anas, "Implementasi Pembelajaran STEM pada Materi Ekosistem terhadap Kemampuan Berpikir Kritis Peserta Didik," *J. Educ.*, vol. 05, no. 04, pp. 11385–11396, 2023.
[37] E. Dewi, A. Rahmi, M. Gade, and K. Karnika, "Penerapan Model Contextual Teaching and Learning Dapat Meningkatkan Keterampilan Berfikir Kritis Pada Materi Sistem Peredaran Darah Manusia Di Smpn 2 Sakti Kabupaten Pidie," *J. Real Ris. |*, vol. 3, no. 3, p. 273, 2021.
[38] I. F. Lestari and S. N. Muhajir, "Pendekatan STEM untuk Meningkatkan Keterampilan Berpikir Kritis Siswa pada Materi Fluida Statis," *J. Pendidik. dan Ilmu Fis.*, vol. 1, no. 2, p. 62, 2021, doi: 10.52434/jpif.v1i2.1483.
[39] Wakijo and S. Suprihatin, "Implementasi Pendekatan Contextual Teaching Learning (CTL) Terhadap Kemampuan Berpikir Kritis Siswa," *J. Pendidik. Ekon. UM Metro*, vol. 53, no. 9, pp. 1689–1699, 2016.
[40] C. D. Putri, I. D. Pursitasari, and B. Rubini, "Problem Based Learning Terintegrasi STEM di Era Pandemi Covid-19 untuk Meningkatkan Keterampilan Berpikir Kritis Siswa," vol. 4, no. 2, pp. 193–204, 2020, doi: 10.24815/jipi.v4i2.17859.
[41] Aminah, D. Novalian, E. Rozal, F. Sulman, and M. Habibi, "STEM Approach in Online Lectures: How Does it Contribute to Cognitive Aspects?," *Indones. J. Sci. Educ.*, vol. 5, no. 2, pp. 88–97, 2021, doi: 10.31002/ijose.v5i2.4365.
[42] Y. Bustami, D. Syafruddin, and R. Afriani, "The implementation of contextual learning to enhance biology students' critical thinking skills," *J. Pendidik. IPA Indones.*, vol. 7, no. 4, pp. 451–457, 2018, doi: 10.15294/jpii.v7i4.11721.
[43] Juniwati and R. P. Sari, "Pengaruh Model Contextual Teaching and Learning (CTL) Pada Pembelajaran IPA Terhadap Keterampilan Berpikir Kritis Peserta Didik," *J. Pendidik. Kim. dan Ilmu Kim.*, vol. 2, no. 2, pp. 38–45, 2019.
[44] H. Simatupang and D. Purnama, *Handbook Best Practice Strategi Belajar*. Surabaya: Pustaka Media Guru, 2019.
[45] A. Muhlisin, "Pengembangan Perangkat Pembelajaran IPA Terpadu Berbasis Contextual Teaching and Learning (CTL) Dengan Model Pembelajaran Kooperatif Tipe Student Teams Achievement Division (STAD) Tema Polusi Udara," *J. Educ. Res. Eval.*, vol. 1, no. 2, pp. 139–145, 2012.

[46] R. Farwati, K. M. Sika, and M. Isnaini, *STEM Education Dukung Merdeka Belajar (Dilengkapi Dengan Contoh Perangkat Pembelajaran Berbasis STEM)*. Riau: Dotplus Publisher, 2020.
[47] S. Silaban and N. S. D. Simangunsong, "Pengaruh Model Pembelajaran Contextual Teaching And Learning (CTL) Terhadap Hasil Belajar Siswa Pada Pokok Bahasan Sistem Koloid," *J. Pendidik. Kim.*, vol. 7, no. 1, pp. 95–101, 2015.

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