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# How Can STEM Approaches Improve Students' Critical Thinking Skills and Communication Skills?

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**Abstract:** This study aims to analyze the influence of the STEM approach on critical thinking skills and communication skills in mathematics subjects of grade V elementary school students. The research method used was a quasi-experimental design with a pretest-posttest control group design. Sampling used the purposive sampling technique in elementary schools in Yogyakarta City, Indonesia. The instruments used to collect data were test questions and observation sheets. The data normality test used Shapiro-Wilk, while the univariate homogeneity test used Levene's. The data were analyzed by paired t-test and independent t-test. The results of the study showed that the STEM approach had a positive and significant effect on the critical thinking ability and communication skills of grade V elementary school students. These results were theoretical and empirical evidence that the STEM approach had conceptual and practical implications in developing students' critical thinking skills and communication skills.

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## Introduction

In the 21st century, individuals must possess knowledge or competencies to navigate the advancements of this period of globalization. Critical and creative thinking, communication, teamwork, creativity, innovation, ICT literacy, contextual learning, and media literacy are the key skills (Martaida et al., 2017). Education in the 21st century possesses distinct qualities, emphasizing the development of abilities pertinent to this era, which encompass: 1) critical thinking, 2) creative and inventive thinking, 3) communication, and 4) teamwork (Rosnaeni, 2021).

Critical thinking is an attitude that involves profound contemplation of challenges within an individual's capacity (Fisher, 2008). Critical thinking abilities facilitate lateral and systematic thinking, particularly in problem-solving contexts (Rachmantika & Wardono, 2019). Critical thinking abilities are not inherent at birth; they necessitate ongoing growth, particularly in fostering attitudes and actions that promote critical thinking (Asriningtyas et al., 2018). An individual demonstrates critical thinking skills if they display five indicators: 1) Fundamental Clarification; 2) Decision Criteria; 3) Inference; 4) Enhanced Clarification; and 5) Hypothesis and Integration. Critical thinking abilities are closely linked to student learning outcomes (Komariyah & Laili, 2018), suggesting that an individual's critical thinking capacity may be assessed through students' learning results.

Communication is an essential foundational ability that every learner must possess. Fundamental talents may be cultivated, honed, and enhanced through educational activities in school. Communication skills are a vital element of soft skills, namely intrapersonal skills, which enhance academic abilities and influence an individual's success in life (Sumaryanta,

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2008). Mathematical communication offers educators critical insight into students' comprehension and expression of mathematical topics and methods (Wardhana & Lutfianto, 2018). Proficient communication abilities are crucial for academic and social achievement (Awaliah, 2023). Communication skills are assessed by four indicators during the learning process: 1) the ability to generate effective ideas and thoughts; 2) the capacity for active listening; 3) proficiency in conveying knowledge; and 4) the use of appropriate and effective language (Budiono & Abdurrohim, 2020).

The necessity of critical thinking and communication abilities for pupils is inversely related to reality. Inadequate critical thinking abilities adversely affect student learning results (Prasasti et al., 2019). The students' deficiency in attention and focus during the learning process, as imparted by teachers, adversely affects their critical thinking abilities, which are comparatively poor (Dores et al., 2020). This is confirmed by the 2018 Programme for International Student Assessment (PISA) Survey findings, which include reading, math, and science scores. According to PISA data, Indonesia ranks 64th out of 65 countries with a score of 382 (OECD, 2019), placing it in the low-performance quadrant with high equity. This suggests that Indonesian students' critical thinking and higher-order cognitive skills are lacking globally. Although PISA's target is 15-year-old students, this indicates that the initial basic concepts that should be possessed since elementary school are not optimal. Consequently, primary school children retain the ability to enhance their critical thinking abilities due to their nascent powers (Lidiawati & Aurelia, 2023). The theoretical research indicates that primary school pupils have not yet developed critical thinking abilities effectively, lack the habit of reading with contemplation, and tend to absorb knowledge only to forget it subsequently.

This theoretical data was corroborated by empirical evidence gathered by the researcher through the collection of papers about the mathematical learning results of fifth-grade students at SDN Jetis 1, SDN Jetis 2, and SDN Jetisharjo in Yogyakarta City, as provided in Table 1.

**Table 1. Mathematics Learning Outcome Data**

| School | Value < 60 | Value ≥ 60 |
|---|---|---|
| SDN Jetis 1 | 75% | 25% |
| SDN Jetis 2 | 63% | 38% |
| SDN Jetisharjo | 83% | 17% |

Table 1 indicates that 75% of students at SDN Jetis 1 scored below 60, 63% of students at SDN Jetis 2 scored below 60, and 83% of students at SDN Jetisharjo scored below 60. Moreover, fifty percent of the mathematics learning outcomes for grade V students at SDN Jetis 1, SDN Jetis 2, and SDN Jetisharjo are below 60, signifying that student performance is insufficient. This learning outcome data relates to the degree of students' critical thinking skills (Komariyah & Laili, 2018).

The researcher observed that pupils in grade V at SDN Jetis 1, SDN Jetis 2, and SDN Jetisharjo encountered challenges in understanding the offered material. They often struggle to integrate disparate data or concepts to derive a coherent conclusion pertinent to the topic matter. Moreover, pupils exhibit deficiencies in addressing questions pertaining to problem-solving in everyday situations. Students have challenges in accurately identifying the appropriate problem-solving strategies when presented with story issues. It might be inferred that pupils' critical thinking abilities remain comparatively deficient and require enhancement.

Rahman & Fujiwijaya (2016) found that mathematical communication encompasses students' capacity to express mathematical concepts using spoken and written language,

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drawings, diagrams, algebraic representations, or mathematical symbols. On the other hand, some perspectives contend that mathematical communication skills encompass the capacity to articulate mathematical ideas both verbally and in writing, as well as the ability to accurately and diligently understand and evaluate the mathematical ideas of others, thereby enhancing comprehension (Lestari & Yudhanegara, 2015).

Students exhibit inadequate communication skills during the learning process, lacking confidence in their replies due to fear of being incorrect and insufficient support from relevant materials or ideas (Yanti & Mashitho, 2024). The communication abilities of each student vary, encompassing both language and non-linguistic dimensions (Reyni, 2020). The deficiency in communication and collaboration skills among students contributes to their struggle in acquiring knowledge, posing a challenge for educators to devise effective learning strategies that enhance students' communication abilities. This aligns with a research by Yoshida et al. (2002) done in Washington, which asserts the necessity of learning that fosters effective communication skills. An effective learning method has been demonstrated to enhance communication abilities.

Research observations were done on fifth-grade students at SDN Jetis 1, SDN Jetis 2, and SDN Jetisharjo revealed various impediments in the learning process. Numerous pupils struggle to articulate their thoughts to address a problem, and some are unable to collaborate with their peers during discussions. Students frequently have the chance to pose inquiries; nevertheless, a limited number exhibit enthusiasm in doing so, primarily due to fear or uncertainty over what to inquire. Furthermore, kids exhibit a deficiency in cultivating their ideas for problem-solving. Students exclusively consult the references provided by the instructor. A significant number of pupils remain inactive, lacking critical thinking skills and hesitating to articulate their thoughts. Therefore, it is imperative to establish a learning paradigm that fosters students' critical thinking and communication skills.

A pedagogical approach is one of the tactics that must be developed within the educational process in order to improve students' critical thinking abilities, particularly their mathematical literacy. The Turkish Ministry of National Education (MoNE) (Acar, 2018) promotes the adoption of STEM approaches in education to improve PISA outcomes. Moreover, STEM methodologies can enhance students' problem-solving abilities, foster motivation in learning, promote positive attitudes, and elevate academic performance, particularly in mathematics and science education (English & King, 2015). Knowledge, technology, engineering, and mathematics are the four key pillars of the STEM (Science, Technology, Engineering, and Mathematics) method. The four Cs of learning creativity, critical thinking, collaboration, and communication are all incorporated within the STEM approach (D. Lestari, 2018).

Observations at SD Negeri Jetis 1 revealed that the employed pedagogical techniques were inadequate. Interviews with homeroom instructors of class V, namely those instructing SR and NV, reveal that mathematics education mostly utilizes traditional, teacher-centered methods, leading to passive learning experiences. This frequently results in pupils experiencing boredom during their learning process. The recent advancement of this study entails the integration of STEM methodologies into mathematics learning activities in elementary schools, with the objective of evaluating the influence of STEM approaches on 21st-century skills, specifically critical thinking and communication competencies among fifth-grade students.

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## Research Method

A quasi-experimental design with a pretest-posttest control group framework is the study approach used. All fourth-grade primary school pupils in Yogyakarta City's Jetis District for the 2023–2024 school year make up the research population. Sampling was conducted via purposive sampling techniques. One school was randomly selected from the current population as a sample. One class was assigned as the experimental group utilizing the STEM methodology, while another class was designated as the control group employing a scientific approach. The courses selected were the VA class of SD Negeri Jetis 1 (experimental group) and the VB class of SD Negeri Jetis 1 (control group).

The instruments employed for data collection are test questions and an observation sheet. The assessment tool was evaluated for content and construct validity, along with practicality, before being administered to students. Five indications make up the assessment of critical thinking ability: 1) basic support; 2) elementary clarification; 3) inference; 4) advanced clarification; and 5) strategy and technique (Ennis et al., 2005). The communication skills observation sheet comprises four indicators: 1) effectively expressing ideas; 2) demonstrating effective listening; 3) articulating information clearly; and 4) utilizing the Indonesian language in a more comprehensible manner (Noviyanti, 2011; Sukmayasa & Sudiana, 2023). Validated and trustworthy critical thinking ability test instruments may thereafter be employed in research. Data analysis processes include bounded variable data analysis, instrument validation data analysis, preliminary research data analysis, and the use of paired sample t-tests, independent sample t-tests, and normality requirement tests to evaluate the efficacy of STEM methodologies.

## Results and Discussion

The research involved assessing the baseline condition of students with a pretest designed to evaluate their critical thinking and communication abilities before the intervention. Subsequent to acquiring early data, the researcher administered distinct treatments to the experimental and control groups. The last phase involves assessing the ultimate state of students' critical thinking and communication abilities following intervention using a posttest. The data collecting tool is a validated and reliable critical thinking skills examination following the testing of its validity and reliability. Pretest and posttest data on pupils' critical thinking abilities are gathered in study using trustworthy and legitimate instruments. Pretest and posttest data about students' critical thinking abilities were collected using assessments, while communication skills data were gathered via observation sheets at both the commencement and conclusion of classes employing the STEM method and those utilizing the scientific approach.

The study data, comprising various scores from the critical thinking ability and communication skills assessments, were evaluated to evaluate the research hypothesis. Prior to the hypothesis test, a precondition assessment was conducted, encompassing normality and homogeneity tests. The Shapiro-Wilk test was employed for normality assessment due to the sample size being fewer than 50, as indicated in Table 2.

**Table 2. Data on the Results of the Normality Test**

| Variable | Significance | | α | Information |
|---|---|---|---|---|
| | Experimental Classes | Control Classes | | |
| *Pretest* KBK | 0,130 | 0,078 | 0,05 | Normal |
| *Posttest* KBK | 0,259 | 0,121 | 0,05 | Normal |
| *Pretest* KK | 0,071 | 0,058 | 0,05 | Normal |

| | | | | |
|---|---|---|---|---|
| *Posttest* KK | 0,588 | 0,063 | 0,05 | Normal |

Table 2 indicates that the significance values of all variables exceed 0.05, thus H0 is accepted. Thus, the pretest and posttest data for critical thinking abilities and communication skills in both the experimental and control groups are considered normally distributed, permitting advancement to the homogeneity test step. The univariate homogeneity test utilized Levene's approach, producing the values presented in Table 3.

**Table 3. Univariate Homogeneity Test Results Data**

| Variable | Significance | α | Information |
|---|---|---|---|
| *Pretest* KBK | 0,927 | 0,05 | Homogen |
| *Posttest* KBK | 0,506 | 0,05 | Homogen |
| *Pretest* KK | 0,882 | 0,05 | Homogen |
| *Posttest* KK | 0,598 | 0,05 | Homogen |

Table 3 demonstrates that the significant values of the univariate homogeneity test for each bounded variable in both the experimental and control groups surpass 0.05, signifying that all study participants are homogenous, hence allowing for additional hypothesis testing. The study data showed a normal and homogeneous distribution, according to the results of the normality and homogeneity tests. The critical thinking and communication skills of students taught using the scientific approach in the control group and the STEM technique in the experimental group were then tested using a hypothesis test.

At a significance level of 0.05, the paired sample t-test yielded a t-calculated value of 5.338 and a significance level of 0.000. The critical thinking abilities pretest and posttest data differed by 5.338, according to the t-test results. With a 0.000 < 0.05 result, H0 is rejected and Ha is accepted, confirming that the STEM method has a significant impact on fifth-grade primary school children' mathematical critical thinking abilities. With a p-value of 0.033, which is less than 0.05, the independent samples t-test revealed a significant difference in the experimental and control groups' final critical thinking skills. As a result, the alternative hypothesis (Ha) was accepted and the null hypothesis (H0) was rejected, indicating that the two classes' critical thinking abilities differed.

The paired sample t-test yielded a t-calculated value of 4.977 and a significance level of 0.000 when run at a significance level of 0.05. The results of the t-test showed that there was a 4.977 difference in communication skills between the pretest and posttest data. STEM techniques had a considerable influence on fifth-grade primary school students' mathematical communication abilities, as seen by the results, which showed a rejection of H0 and an acceptance of Ha at 0.000 < 0.05. With a p-value of 0.034, which is less than 0.05, the independent samples t-test revealed a significant difference between the experimental and control groups' final communication skills. Consequently, the alternative hypothesis (Ha) was confirmed and the null hypothesis (H0) was rejected, indicating that the two groups' communication skills results differed.

## Discussion

### *The Effect of STEM on Critical Thinking Skills*

The results of the hypothesis testing show that the STEM approach improves fifth-grade primary pupils' critical thinking skills. Students in the experimental group improved their critical thinking abilities more than those in the control group in every parameter, according to the descriptive statistical analysis. The experimental class's average score continuously improved due to the pupils' improved critical thinking abilities. The final assessment indicates that most students have advanced critical thinking skills, while their initial critical thinking abilities mostly fall into the medium level.

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Although the number of students classified as high has increased, the majority of students in the control group's initial and final critical thinking scores fall into the poor category. This occurs because STEM techniques foster the development of critical thinking abilities. The results of Davidi et al. (2021) and Ardianti et al. (2020) support the idea that using STEM methods in the classroom improves students' critical thinking abilities. The introduction of complex challenges inside the STEM framework drives students to investigate concerns, formulate solutions, and assess hypotheses, requiring critical thinking skills during execution.

The pre-treatment data analysis revealed that the students' critical thinking skills were categorized within the medium range, as demonstrated by an average pretest score of 23.8 in the experimental class. This happens because the used learning methodologies do not provide students with the opportunity to develop critical thinking skills during the educational process. A strategy that inadequately engages learners in the educational process undermines their motivation and participation. Student engagement in the learning process is crucial for developing critical thinking skills (Yanwar et al., 2023).

The examination and clarification of the pretest data about the participants' critical thinking abilities were thereafter succeeded by the use of a therapy employing a STEM methodology. The average score of the students' critical thinking abilities improved to 34.17 on a posttest that the researcher administered to them after the therapy. A significant influence of the STEM method on the critical thinking skills of fifth-grade primary students is shown by the gis value of 0.000, which is below 0.05, which comes from calculations on the effect of the STEM approach on children's critical thinking abilities.

The findings of this study align with those of Dywan & Airlanda (2020) and Sumarni & Kadarwati (2020), demonstrating that the integration of the STEM approach with the PjBL model greatly enhances students' critical thinking skills. Putri et al. (2020) demonstrated that the integration of a STEM approach with the PBL paradigm enhanced students' critical thinking skills. The STEM method incorporates many disciplines, allowing students to assess problems from various perspectives and consider different factors before making decisions or developing solutions for tasks. These activities aim to improve students' critical and analytical thinking abilities.

Students enhance their critical thinking abilities by engaging in activities that facilitate the construction of their own knowledge derived from educational experiences (Ariyatun & Octavianelis, 2020). Scientific activities within the STEM framework, including observations, hypotheses, experiments, data analysis, and conclusions, directly cultivate students' critical thinking abilities (Asigigan & Samur, 2021). The STEM method also impacts kids' problem-solving abilities and creativity in learning (Rahman et al., 2023). The aforementioned presentations show the findings of a review on the use of STEM, which actively engages students in the learning process and enhances their critical thinking abilities essential for making judgments on everyday challenges.

***The Influence of STEM on Communication Skills***

The conducted hypothesis testing has yielded data indicating that the STEM approach positively impacts the communication abilities of fifth-grade primary children. The statistical analysis demonstrated that the enhancement in communication abilities in the experimental group surpassed that of the control group. The communication abilities of students in the experimental class significantly enhanced the average score. The students' initial communication skills are primarily categorized as extremely low; nevertheless, most demonstrate medium-level critical thinking ability at the end of the exam. The beginning communication skills of students in the control group were predominantly classified as

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extremely poor, whereas the end communication skills were primarily categorized as low. This may occur due to the cultivation of communication skills using STEM methodologies. Consistent with the findings of Putri & Subali (2023) and Yulianti & Handayani (2021), it is evident that a STEM approach to learning effectively enhances students' communication abilities. The pretest data analysis revealed that students' communication skills were categorized among the extremely weak group, as demonstrated by an average score of 48.13 in the experimental class. This transpires due to the used pedagogical approaches failing to promote the enhancement of communication abilities in pupils throughout the educational process. An ineffective way of engaging pupils in the study group reduces their engagement in the learning process.

The participation of engaged students in the learning process is essential for the development of communication skills (Mamluatul et al., 2015).The evaluation and explanation of the pretest data on the students' communication abilities were followed by treatment utilizing the STEM method. Subsequent to the treatment, the researcher administered a posttest to the students, yielding an enhancement in the average score of their communication abilities to 60.3. The calculations indicate that the significance value is 0.000, which is less than 0.05, demonstrating that the STEM approach significantly influences the communication abilities of fifth-grade primary school pupils.The findings of this study align with the research by Mawaddah & Mahmudi (2021), which indicates that a STEM approach linked with PjBL enhances students' communication abilities. Inayah et al. (2022) conducted further study demonstrating that the integration of the STEM approach with modules enhances students' communication abilities. This results from STEM approach activities that necessitate students to exchange ideas, allocate tasks, and synchronize their efforts to attain a shared objective.The communication abilities of students, demonstrated via concept discussions, project compilation, and presentations, reflect active practice of these skills. The STEM method may serve as a viable option to enhance students' communication abilities (Fiorintina et al., 2023). Moreover, STEM methodologies can enhance dynamic and interactive learning, broaden students' comprehension, and address the demand for adaptable and creative educational practices (Wedy & Desnita, 2024). The aforementioned presentations show the findings of a review on the implementation of STEM, which effectively engages students in the learning process and enhances their communication skills essential for problem-solving and decision-making.

This research reinforces the theoretical foundation that the use of the STEM method correlates positively with the enhancement of critical thinking and communication abilities. This aligns with the 21st-century needs emphasizing the cultivation of critical thinking and communication abilities. These skills are discerned through targeted learning processes in STEM contexts to find certain STEM competencies that enhance critical thinking and communication abilities. The findings of this research may serve as a foundation for creating a curriculum that incorporates additional STEM components and prioritizes the enhancement of critical thinking and communication skills. Enhancing pedagogical approaches and employing suitable technology to facilitate STEM education and the cultivation of 21st-century competencies. The research findings may serve as a reference for the establishment of teacher training programs aimed at enhancing their proficiency in executing STEM education.

## Conclusion

This study empirically demonstrates the effect of the STEM approach on students' critical thinking and communication abilities. STEM projects often tackle real-world

problems that need students to assess situations, acquire information, and devise innovative solutions. This method fosters critical and logical reasoning in children. STEM includes science, technology, engineering, and mathematics. Students develop the capacity to integrate concepts from several disciplines, allowing them to examine challenges from diverse perspectives and devise comprehensive solutions. STEM projects frequently necessitate collaborative efforts, compelling students to exchange ideas and perspectives with their classmates. Students must articulate scientific or technical topics to their peers in a comprehensible manner. Through collaboration, students acquire the skills to attentively consider others' perspectives, offer constructive criticism, and achieve consensus.

## Recommendation

According to the findings of this research, the author advises educators to integrate STEM across diverse courses by optimizing problem-based learning and using technology. The imperative of STEM in education motivates educators and researchers to enhance their competencies through ongoing training, experience sharing among educational stakeholders, self-reflection, and collaboration with researchers in contextual studies. The author recommends future study to concentrate on complete learning outcomes and the creation of accurate and reliable measures.

## References

Acar, M. G. C. (2018). Determines of capital structure: Empirical evidence from Turkey. *Journal of Management and Sustainability*, *8*(1), 31–45.

Ardianti, S., Sulisworo, D., Pramudya, Y., & Raharjo, W. (2020). The impact of the use of STEM education approach on the blended learning to improve student's critical thinking skills. *Universal Journal of Educational Research*, *8*(3 B), 24–32. https://doi.org/10.13189/ujer.2020.081503

Ariyatun, A., & Octavianelis, D. F. (2020). Pengaruh Model Problem Based Learning Terintegrasi Stem Terhadap Kemampuan Berpikir Kritis Siswa. *JEC: Journal of Educational Chemistry*, *2*(1), 33. https://doi.org/10.21580/jec.2020.2.1.5434

Asigigan, S. I., & Samur, Y. (2021). The effect of gamified stem practices on students' intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills. *International Journal of Education in Mathematics, Science and Technology*, *9*(2), 332–352. https://doi.org/10.46328/IJEMST.1157

Asriningtyas, A. N., Kristin, F., & Anugraheni, I. (2018). Penerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar dan Kemampuan Berpikir Kritis Matematika pada Siswa Kelas IV Sekolah Dasar. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *5*(1), 23–32. https://doi.org/https://doi.org/10.26714/jkpm.5.1.2018.23-32

Awaliah, N. P. (2023). Analisis Pengembangan Keterampilan Komunikasi pada Siswa SD Kelas VI SDIT Al-Madinah Pekanbaru. *Jurnal Pendidikan Guru Sekolah Dasar*, *4*(2), 480–498.

Budiono, H., & Abdurrohim, M. (2020). Peran Guru Dalam Mengembangkan Keterampilan Komunikasi (Communication) Siswa Kelas V Sekolah Dasar Negeri Teratai. *Jurnal IKA PGSD (Ikatan Alumni PGSD) UNARS*, *8*(1), 119. https://doi.org/10.36841/pgsdunars.v8i1.589

Davidi, E. I. N., Sennen, E., & Supardi, K. (2021). Intergrasi Pendekatan STEM Untuk Peningkatan Keterampilan Berpikir Kritis Siswa Sekolah Dasar. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, *11 No. 1*, 11–22.

Dores, O. J., Wibowo, D. C., & Susanti, S. (2020). Analisis kemampuan berpikir kritis siswa pada mata pelajaran matematika. *J-PiMat : Jurnal Pendidikan Matematika*, *2*(2), 242–254. https://doi.org/10.31932/j-pimat.v2i2.889

Dywan, A. A., & Airlanda, G. S. (2020). Efektivitas Model Pembelajaran Project Based Learning Berbasis STEM dan Tidak Berbasis STEM terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Basicedu*, *4*(2), 344–354. https://doi.org/10.31004/basicedu.v4i2.353

English, L., & King, D. (2015). STEM learning through engineering design: Fourth-grade students' investigations in aerospace. *International Journal of STEM Education*, *2*(1).

Ennis, R., Millman, J., & Tomko, T. (2005). *Cornell Critical Thinking Tests.* The Critical Thinking Co.

Fiorintina, E., Sukmaningrum, A., Rohana, S., & ... (2023). Pendekatan Stem Dalam Mendukung Pembelajaran Era Digitalisasi Abad 21 Tingkat Sekolah Dasar. *Prosiding Seminar Nasional Hasil Riser Dan Pengabdian*, *2022*, 3078–3085.

Fisher, A. (2008). *Berpikir Kritis Sebuah Pengantar.* Erlangga.

Inayah, R., Aswirna, P., & Asrar, A. (2022). Keterampilan Komunikasi Peserta Didik. *JOURNAL CERDAS MAHASISWA Fakultas Tarbiyah Dan Keguruan UIN IB Padang*, 78–90. https://doi.org/https://doi.org/10.15548/jcm.v4i2.4784

Komariyah, S., & Laili, A. F. N. (2018). Pengaruh berpikir kritis terhadap hasil belajar matematika. *JP3M: Jurnal Penelitian Pendidikan Dan Pengajaran Matematika*, *4*(2), 55–60. https://doi.org/https://doi.org/10.37058/jp3m.v4i2.523

Lestari, D. (2018). Implementasi LKS Dengan Pendekatan STEM (Science, Technology, Engineering, And Mathematics) Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan Fisika Dan Teknologi*, *4*(1), 202–207.

Lestari, K. E., & Yudhanegara, M. R. (2015). *Penelitian Pendidikan Matematika.* Refika Aditama.

Lidiawati, K. R., & Aurelia, T. (2023). Kemampuan Berpikir Kritis Siswa di Indonesia: Rendah atau Tinggi? *Konsorium Psikologi Ilmiah Nusantara*, *9*(2). https://buletin.k-pin.org/index.php/arsip-artikel/1200-kemampuan-berpikir-kritis-siswa-di-indonesia-rendah-atau-tinggi

Mamluatul, H., Santosa, D., & Subarno, A. (2015). Pengaruh keaktifan siswa dalam pembelajaran dan praktek kerja lapangan terhadap kemampuan komunikasi interpersonal siswa kelas xii jurusan administrasi perkantoran SMK Negeri 1 Surakarta. *Urnal Pendidikan Administrasi Perkantoran Universitas Sebelas Maret*, *1*.

Martaida, T., Bukit, N., & Ginting, M. . (2017). The Effect of Discovery Learning Model on Student's CriticalThinking and Cognitive Ability in Junior High School. *IOSR Journal of Research & Method in Education*, *7*(6), 1–8. http://www.iosrjournals.org/

Mawaddah, S., & Mahmudi, A. (2021). Analisis Kemampuan Komunikasi Matematika Siswa Melalui Penggunaan Project-Based Learning Terintegrasi Stem. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(1), 167.

Noviyanti, M. (2011). Pengaruh Motivasi dan Keterampilan Berkomunikasi Terhadap Prestasi Belajar Mahapeserta didik Pada Tutorial Online Berbasis Pendekatan Kontekstual Pada Mata Kuliah Statistika Pendidikan. *Jurnal Pendidikan*, *12*(2), 80–88. https://doi.org/https://doi.org/10.33830/jp.v12i2.494.2011

OECD. (2019). Results from PISA 2018: Indonesia. *OECD Publishing*, *I*. https://doi.org/10.1787/g222d18af-en

Prasasti, D. E., Koeswanti, H. D., & Giarti, S. (2019). Peningkatan Keterampilan Berpikir Kritis Dan Hasil Belajar Matematika Melalui Model Discovery Learning Di Kelas Iv

Sd. *Jurnal Basicedu*, *3*(1), 174–179. https://doi.org/10.31004/basicedu.v3i1.98

Putri, C. D., Pursitasari*, I. D., & Rubini, B. (2020). Problem Based Learning Terintegrasi STEM Di Era Pandemi Covid-19 Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *Jurnal IPA & Pembelajaran IPA*, *4*(2), 193–204.

Putri, R. E., & Subali, B. (2023). Penerapan pendekatan stem pada pembelajaran fisika materi suhu dan kalor dengan bantuan media flashcard untuk meningkatkan kemampuan komunikasi siswa. *Prosiding Seminar Nasional Fisika*, *35*, 527–539.

Rachmantika, A. R., & Wardono. (2019). Peran Kemampuan Berpikir Kritis Siswa Pada Pembelajaran Matematika Dengan Pemecahan Masalah. *Prosiding Seminar Nasional Matematika*, *2*(1), 441.

Rahman, A., Suharyat, Y., Ilwandri, I., Santosa, T. A., Sofianora, A., Gunawan, R. G., & Putra, R. (2023). Meta-Analisis : Pengaruh Pendekatan STEM berbasis Etnosains Terhadap Kemampuan Pemecahan Masalah dan Berpikir Kreatif Siswa. *Innovative: Journal Of Social Science Research*, *3*(2), 2111–2125. https://doi.org/10.31004/innovative.v3i2.545

Reyni. (2020). *Peningkatan keterampilan komunikasi siswa kelas III SD melalui model pembelajaran kooperatif round robin*. *8*(4), 189–197. https://journal.ipts.ac.id/index.php/ED/article/download/2099/1103

Rosnaeni. (2021). Karakteristik dan Asesmen Pembelajaran Abad 21. *Jurnal Basicedu*, *5*(5), 4334 – 4339. https://doi.org/http://dx.doi.org/10.31004/basicedu.v5i5.1548

Sukmayasa, I. M. H., & Sudiana, I. N. (2023). The effect of the whole language approach on learning motivation and productive communication skills of students. *Advances in Mobile Learning Educational Research*, *3*(1), 596–601.

Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Sumaryanta. (2008). *Pengembangan Soft Skills dalam Pembelajaran Matematika.* http://www.p4tkmatematika.org

Wardhana, I. R., & Lutfianto, M. (2018). Analisis kemampuan komunikasi matematis Siswa Ditinjau dari kemampuan matematika siswa. *Jurnal Pembelajaran Berpikir Matematika (Journal of Mathematics Thinking Learning)*, *6*(2), 173–184. https://core.ac.uk/download/pdf/230371775.pdf

Wedy, Z. S., & Desnita. (2024). Studi literatur: pengaruh penggunaan LKPD berbasis elektronik menggunakan pendekatan STEM untuk meningkatkan keterampilan abad 21 peserta didik. *Silampari Jurnal Pendidikan Ilmu Fisika*, *6*(1), 138–151.

Yanti, Y. E., & Mashitho, D. (2024). Hubungan literasi membaca dengan keterampilan komunikasi siswa kelas V SD negeri di desa Bangelan kecamatan Wonosari. *Primary Education Journal*, *4*(1), 106–113.

Yanwar, I. M., Sri Darmayani, I. G. A., Ganesha, I. G. H., & Mayura, I. P. B. (2023). Hubungan kemampuan berpikir kritis terhadap keaktifan belajar pada mahasiswa sarjana kedokteran Universitas Udayana. *Intisari Sains Medis*, *14*(1), 77–80. https://doi.org/10.15562/ism.v14i1.1586

Yoshida, T., Milgrom, P., & Coldwell, S. (2002). How do US and Canadian dental schools teach interpersonal communication skills? *Journal of Dental Education*, *66*(11), 1281–1288.

Yulianti, D., & Handayani, E. (2021). Enhancement of communication skills through physics learning with science, technology, engineering, and mathematics (stem) approach. *Journal of Physics: Conference Series*, *1918*(5).