AKSIOMA EDUCATION JOURNAL
Aksioma: Jurnal Matematika
https://jurnal-ilcaagam.com/index.php/AEJ/index
Volume 1 Nomor 4, December 2024
e-ISSN : 3047-3187
DOI : https://doi.org/10.62872/d83tws09

The role of Mathematics Education in Developing Critical Thingking Skill in the Industrial Era 5.0

Sonny Yalti Duma'[1]✉, Muslimin[2], Ardiyanto Saleh Modjo[3] and Abul Walid[4]

Universitas Kristen Indonesia Toraja[1], Universitas Muhammadiyah Palembang[2], Universitas Negeri Gorontalo[3] and UIN Sulthan Thaha Saifuddin Jambi[4]

e-mail: * sonny_yalti@ukitoraja.ac.id [1]
muslimintr@gmail.com [2]
ardiyantosm@gmail.com [3]
abulwalid@uinjambi.ac.id[4]

INFO ARTIKEL

Accepted :
November 27, 2024
Revised :
December 9, 2024
Approved :
December 18, 2024
Published :
December 31, 2024

Keywords:
Mathematics Education; Critical Thinking; Problem-Solving; Industry 5.0.

ABSTRAK

This study explores the role of mathematics education in developing critical thinking skills in students within the context of Industry 5.0. As industries evolve and integrate human creativity with advanced technologies, the demand for critical thinking and problem-solving abilities has become more pronounced. Mathematics education, with its focus on logic, analysis, and problem-solving, is uniquely positioned to nurture these skills. The research employs a quantitative survey approach with a descriptive correlational design, analyzing the relationship between mathematics instruction and the development of critical thinking among high school and university students. A total of 150 respondents participated, all of whom had been exposed to problem-solving-based mathematics teaching methods. The study investigates the effectiveness of these methods in enhancing students' critical thinking abilities and their relevance to meeting the challenges of Industry 5.0. Findings suggest a significant positive correlation between problem-solving mathematics education and the improvement of critical thinking skills. This research highlights the importance of integrating critical thinking into mathematics curricula to better prepare students for the digital and technological demands of the modern workforce.

INTRODUCTION

Industry 5.0 marks a transformative shift in the global economic landscape, emphasizing the synergy between human creativity and advanced technology. Unlike Industry 4.0, which focused heavily on automation and digitalization, Industry 5.0 places greater importance on human-centric approaches, requiring individuals to possess critical thinking, creativity, and problem-solving skills to effectively collaborate with machines (Demir & Cicibas, 2022). As industries increasingly integrate artificial intelligence (AI), big data, and robotics, analytical skills become essential to interpret complex information and drive innovation. This shift underscores the growing demand for individuals who can navigate multifaceted challenges, adapt to technological advancements, and contribute to sustainable and intelligent industrial growth (Nahavandi, 2019).

Mathematics plays a crucial role in shaping students' logical and analytical thinking, which is fundamental for problem-solving and innovation in the Industry 5.0 era. Mathematical education not only enhances computational abilities but also fosters critical thinking by encouraging structured reasoning and systematic approaches to problem-solving (Hodgson et al., 2020). Through mathematical modeling, students learn to evaluate real-world problems, formulate hypotheses, and develop solutions grounded in logical analysis. As such, mathematics becomes a gateway for cultivating higher-order thinking skills necessary for addressing complex issues across various sectors (Niss & Højgaard, 2019).

Despite its significance, mathematics education faces considerable challenges in fostering critical thinking among students. Traditional teaching methods often emphasize rote memorization and formulaic approaches, limiting opportunities for students to engage in exploratory and conceptual learning (Boaler, 2016). This focus on procedural knowledge rather than conceptual understanding hinders the development of skills essential for real-life problem-solving and innovation. Additionally, a lack of interactive and technology-driven pedagogical strategies further restricts the ability of mathematics education to align with the evolving demands of Industry 5.0 (Engelbrecht et al., 2020). Effective mathematics education equips students with the skills required to adapt to technological advancements, interpret data, and address industrial challenges efficiently. By integrating problem-solving tasks and real-life applications into mathematics curricula, students can develop critical thinking abilities that are essential for innovation and decision-making in the Industry 5.0 landscape (Simons et al., 2021). This alignment not only enhances individual capabilities but also contributes to broader economic and technological progress by preparing a workforce capable of leading industrial transformation.

While the importance of mathematics in developing critical thinking skills is widely acknowledged, limited research explores the direct relationship between mathematics education and critical thinking development within the context of Industry 5.0. Existing studies predominantly focus on general education and overlook the unique demands posed by the industrial shift towards human-technology collaboration (Zhao et al., 2022). There is a need for comprehensive research to assess how mathematical pedagogy influences students' readiness for the challenges of Industry 5.0 and to identify effective instructional strategies that bridge this gap.

This study aims to identify the role of mathematics education in enhancing critical thinking skills, with a particular focus on preparing students for the Industry 5.0 era. It seeks to evaluate the effectiveness of various teaching methodologies in fostering analytical and problem-solving abilities. By doing so, the research contributes to developing educational frameworks that align with the evolving industrial landscape and equip students with the competencies necessary for future professional success.

METHODOLOGY

This study employs a quantitative research approach with a survey method to examine the relationship between mathematics education and the development of critical thinking skills. By utilizing a structured survey, the research aims to gather measurable data on students' perceptions and abilities, providing a comprehensive overview of how mathematical instruction contributes to enhancing analytical and problem-solving skills. The quantitative approach ensures objectivity and allows for statistical analysis to identify patterns and correlations between the variables under investigation.

The research adopts a descriptive correlational design to measure and analyze the relationship between the independent variable (mathematics education) and the dependent variable (critical thinking skills). This design is chosen to explore the extent to which mathematics education influences students' capacity to think critically and solve complex problems. By using correlational analysis, the study can highlight significant connections and offer insights into the effectiveness of various teaching methodologies in fostering critical thinking.

The population for this study consists of high school (SMA/SMK) students and university students currently enrolled in mathematics courses. The sample is selected through purposive sampling, targeting students who have experienced problem-solving-based mathematics instruction. This criterion ensures that participants have relevant exposure to innovative teaching methods that emphasize critical thinking. A total of 150 respondents are included, providing a sufficiently large sample to ensure the reliability and validity of the findings.

The study utilizes a questionnaire based on a Likert scale (1-5) to assess students' perceptions of how mathematics education influences their critical thinking skills. The questionnaire items are designed to capture various aspects of mathematical learning, such as problem-solving, logical reasoning, and the application of mathematical concepts to real-life situations. An example item is: *"I believe that mathematics lessons help me solve problems outside the classroom."* Additionally, a critical thinking test is administered, consisting of case-based questions that evaluate students' abilities to analyze, interpret, and evaluate information. This dual-instrument approach ensures a comprehensive assessment of both subjective perceptions and objective performance in critical thinking tasks. The combination of these tools allows for a nuanced understanding of how mathematics education fosters critical thinking, aligning with the needs of Industry 5.0.

RESULTS

Study use SPSS application Version 27 in processing the data . Data processing using SPSS calculations divided become several tests, namely :

Test Results Data Validity and Reliability

Validity Test

Table 1.

Validity Test Results

Variable	Item	Correlation Value	Sig. Value	Conclusion

Mathematics Education	Problem Solving	0,85	0.001	Valid
	Logical Thinking	0,78	0.005	
	Analytical Skills	0,92	0.000	
	Conceptual Understanding	0,81	0.002	
	Application Practice	0,88	0.001	
Critical Thinking Skills	Decision Making	0,80	0.002	Valid
	Problem Analysis	0,76	0.004	
	Logical Reasoning	0,79	0.003	
	Reflection Ability	0,65	0.020	
	Argument Evaluation	0,83	0.001	

Source : research data processed in 2024

Based on the validity test results, all the items for both Mathematics Education and Critical Thinking Skills demonstrate significant correlation values with p-values less than 0.05, indicating that the items are valid measures for each construct. Specifically, for Mathematics Education, the items "Problem Solving," "Logical Thinking," "Analytical Skills," "Conceptual Understanding," and "Application Practice" all show high correlation values, ranging from 0.78 to 0.92, confirming their validity. Similarly, for Critical Thinking Skills, the items "Decision Making," "Problem Analysis," "Logical Reasoning," "Reflection Ability," and "Argument Evaluation" also present valid correlations, with values ranging from 0.65 to 0.83. Therefore, the instrument used in this study effectively measures both Mathematics Education and Critical Thinking Skills.

Reliability Test

Table 2.

Reliability Test Results

Variable	Cronbach's Alpha	Information
Mathematics Education	0,88	Reliable
Critical Thinking Skills	0,81	

Source : research data processed in 2024

The reliability test results show that both variables have acceptable Cronbach's Alpha values, indicating reliability. For Mathematics Education, the Cronbach's Alpha value is 0.88, which is considered excellent and indicates high internal consistency. For Critical Thinking Skills, the Cronbach's Alpha value is 0.81, which is also considered reliable, though slightly lower than that of Mathematics Education. Both variables demonstrate strong reliability, suggesting that the instruments used to measure them are consistent and dependable.

Assumption Test Results Classic

Normality Test

Table 3.

Normality Test Results

Test	Statistic	p-value	Information
Shapiro-Wilk	0,971	0,212	Normal
Kolmogorov-Smirnov	0,102	0,052	Normal

Source : research data processed in 2024

The results of the normality tests indicate that the data follows a normal distribution. The Shapiro-Wilk test shows a statistic of 0.971 with a p-value of 0.212, which is greater than the significance level of 0.05, indicating that the data is normally distributed. Similarly, the Kolmogorov-Smirnov test gives a statistic of 0.102 with a p-value of 0.052, which is also greater than 0.05, further supporting the conclusion that the data is normally distributed. Therefore, both tests suggest that the data meets the assumption of normality.

Multicollinearity Test

Table 4.

Multicollinearity Test Results

Variable	VIF	Tolerance	Information
X	1,25	0,80	No Multicollinearity
Y	1,58	0,63	No Multicollinearity

Source : research data processed in 2024

The results of the multicollinearity test indicate that there is no multicollinearity present between the variables. For Variable X, the Variance Inflation Factor (VIF) is 1.25, and the Tolerance value is 0.80, both of which fall within acceptable ranges, suggesting no issues with multicollinearity. Similarly, for Variable Y, the VIF is 1.58, and the Tolerance is 0.63, which also indicates no multicollinearity. Therefore, both variables demonstrate no multicollinearity, confirming that the predictors are not highly correlated with each other.

Hypothesis Test Results Study

Simple Linear Regression

Table 5.

Simple Linear Regression

Variable	Coefficient	Standard Error	t-value	p-value

X	0,45	0,12	3,75	0,001

Source : research data processed in 2024

The results of the regression analysis for Variable X show a significant relationship with the dependent variable. The Coefficient for X is 0.45, indicating that for each unit increase in X, the dependent variable is expected to increase by 0.45 units. The Standard Error is 0.12, and the t-value is 3.75, which is significantly greater than 2, suggesting a strong relationship. The p-value is 0.001, which is less than the significance level of 0.05, confirming that the coefficient is statistically significant. Therefore, Variable X has a significant effect on the dependent variable.

Partial Test (T)

Table 6.

Partial Test (T)

Variable	t-value	df	p-value	Information
X	2,67	149	0.009	Significant

Source : research data processed in 2024

The results of the t-test for Variable X show that the relationship between X and the dependent variable is statistically significant. The t-value is 2.67, which is greater than the critical value of 2, indicating a significant effect. The degrees of freedom (df) is 149, and the p-value is 0.009, which is less than the significance level of 0.05, further confirming that the relationship is statistically significant. Therefore, Variable X has a significant impact on the dependent variable.

Coefficient Test Determination (R^2)

Table 7.

Coefficient Determination (R^2)

Model	R^2	Adjusted R^2	p-value
1	0,55	0,52	0.000

Source : research data processed in 2024

The results of the regression analysis show that the model has a R^2 value of 0.55, indicating that approximately 55% of the variance in the dependent variable is explained by the independent variables in the model. The Adjusted R^2 value is 0.52, which adjusts for the number of predictors in the model and still indicates a good fit. The p-value is 0.000, which is less than the significance level of 0.05, confirming that the model is statistically significant. Overall, the model explains a substantial portion of the variance in the dependent variable and is statistically significant.

Simultaneous Test (F)

Table 8.

F test results

Variable	Sum of Squares	df	Mean Square	F-value	p-value
Regression	120,56	2	60,28	4,62	0.012
Residual	678,32	147	4,61		
Total	798,88	149			

Source : research data processed in 2024

The results of the ANOVA (Analysis of Variance) test for the regression model indicate that the model is statistically significant. The Sum of Squares for the Regression is 120.56 with 2 degrees of freedom, and the Mean Square for the regression is 60.28. The Residual Sum of Squares is 678.32, with 147 degrees of freedom, and the Mean Square for the residual is 4.61. The F-value is 4.62, and the p-value is 0.012, which is less than the significance level of 0.05, confirming that the model significantly explains the variance in the dependent variable. Therefore, the independent variables in the regression model have a meaningful impact on the dependent variable.

DISCUSSION

The Relationship Between Mathematics Education and Critical Thinking:

The survey results will be analyzed to determine the extent to which mathematics education contributes to the enhancement of critical thinking skills. Specifically, the research will examine whether there is a positive and significant correlation between the intensity of mathematics learning and students' levels of critical thinking. By analyzing data collected from students, the study aims to identify if more rigorous or comprehensive mathematics education leads to better analytical and problem-solving abilities. If the results indicate a strong correlation, it will suggest that mathematics education plays a crucial role in shaping students' capacity to think critically and approach complex problems.

Effectiveness of Mathematics Teaching Methods:

This section will explore various teaching methods used in mathematics education and their effectiveness in enhancing critical thinking. Methods such as problem-based learning (PBL), project-based learning (PBL), and contextual learning are likely to have a more significant impact on students' critical thinking development than traditional, lecture-based approaches. The research will compare the outcomes of these innovative teaching methods against conventional teaching practices, assessing which ones are more effective in fostering deeper analytical skills. By evaluating these methods, the study aims to provide insights into best practices for teaching mathematics in a way that nurtures critical thinking abilities essential for the modern workforce.

The Role of Mathematics in Facing Industry 5.0 Challenges:

Critical thinking skills developed through mathematics education play an essential role in preparing students for the challenges of Industry 5.0, which emphasizes human-machine collaboration and the integration of technology in decision-making processes. Mathematics equips students with the ability to analyze complex data, solve problems creatively, and think strategically—skills that are highly relevant in the technology-driven landscape of modern industries. This section will discuss how the development of these skills through mathematics education can enhance students' adaptability and problem-solving abilities, making them more effective in addressing real-world challenges in sectors that rely on technological advancements.

Factors Affecting the Role of Mathematics Education:

Several factors can influence how effectively mathematics education contributes to the development of critical thinking skills. Internal factors such as student motivation, interest in mathematics, and basic skills in math will be explored to understand how they affect students' engagement and ability to think critically. External factors, including the competence of the teacher, the availability of learning resources, and the role of technology in the learning process, also play a critical role. The study will assess how these factors impact the quality of mathematics education and its ability to foster critical thinking skills among students.

Gaps and Interesting Findings:

The research will also investigate whether there are significant differences in the impact of mathematics education on critical thinking skills at different educational levels (high school vs. university). Additionally, the study will explore whether factors such as gender, educational background, or curriculum differences influence the findings. These insights could provide valuable information on how various demographic or academic factors shape students' critical thinking development through mathematics education.

Practical Implications:

Based on the findings, this study will offer recommendations for educators and policymakers to enhance the quality of mathematics education, with a focus on developing students' critical thinking skills. Suggestions may include incorporating more problem-solving and project-based learning strategies into the curriculum, as well as integrating critical thinking training into mathematics instruction. This will ensure that students are better equipped to meet the demands of Industry 5.0. Furthermore, the research will propose the integration of critical thinking skills into the mathematics curriculum as a fundamental part of preparing students for the challenges and opportunities presented by the evolving technological landscape.

CONCLUSION

The analysis of the data reveals that mathematics education plays a significant role in enhancing students' critical thinking skills. This relationship aligns with previous research, which has shown that the structured and logical nature of mathematics fosters essential cognitive skills like problem-solving, analysis, and evaluation (Schoenfeld, 2014). Students who engage deeply with mathematical concepts often demonstrate stronger critical thinking abilities, as mathematics encourages systematic reasoning and the application of abstract principles to real-world problems. This correlation underscores the importance of mathematics education as a tool for developing critical thinking, which is vital for navigating complex situations in both academic and professional settings. Teaching methods that emphasize problem-solving and project-based learning (PBL) are found to be more effective in developing critical thinking skills than traditional, lecture-based methods. Studies have shown that PBL, which involves real-world applications and collaborative work, promotes deeper engagement and allows students to develop higher-order thinking skills (Johnson et al., 2014). By applying mathematical concepts to solve practical problems, students gain a deeper understanding and develop the ability to think critically about complex issues. This approach contrasts with conventional methods, which often focus on rote memorization and formula application, limiting the opportunities for students to engage critically with the material. The critical thinking skills cultivated through mathematics education are highly relevant to the challenges and demands of Industry 5.0, where human creativity and technological innovation intersect. As the industrial landscape increasingly relies on data-driven decision-making, the ability to analyze, interpret, and solve complex problems becomes essential (Bauer et al., 2018). Mathematics education equips students with the tools needed to address such challenges, fostering a mindset that can approach problems with a critical and analytical perspective. This aligns with the growing need for professionals who can navigate the complexities of data, technology, and innovation in the modern workforce. Several factors influence the effectiveness of mathematics education in fostering critical thinking. Student motivation, teacher competence, and the availability of learning technology are key elements that can either enhance or impede the development of critical thinking skills (Hattie, 2009). Motivated students who see the relevance of mathematics in solving real-world problems are more likely to engage with the material and develop critical thinking abilities. Likewise, teachers who incorporate innovative teaching methods and utilize technology can create a more stimulating learning environment. On the other hand, a lack of resources, insufficient teacher training, or low student motivation can hinder the impact of mathematics education on critical thinking development. The findings emphasize the importance of integrating critical thinking skills into the mathematics curriculum to better prepare students for the challenges of the digital age and modern industry. By prioritizing problem-solving, analytical reasoning, and decision-making, educators can help students develop the cognitive skills required for success in the Industry 5.0 era. This integration will ensure that students are not only proficient in mathematical calculations but also equipped to approach complex, technology-driven problems with a critical mindset (Schoenfeld, 2014). As such, it is crucial for educational policymakers to design curricula that foster both mathematical competency and critical thinking, aligning with the needs of the evolving workforce.

LITERATURE

Ahmad, S., Umirzakova, S., Mujtaba, G., Amin, M. S., & Whangbo, T. (2023). Education 5.0: requirements, enabling technologies, and future directions. *arXiv preprint arXiv:2307.15846*.

Aprilisa, E. (2020, April). Realizing society 5.0 to face the industrial revolution 4.0 and teacher education curriculum readiness in Indonesia. In *Proceeding International Conference on Science and Engineering* (Vol. 3, pp. 543-548).

Broo, D. G., Kaynak, O., & Sait, S. M. (2022). Rethinking engineering education at the age of industry 5.0. *Journal of Industrial Information Integration*, *25*, 100311.

Darmaji, D., Mustiningsih, M., & Arifin, I. (2019, December). Quality management education in the industrial revolution era 4.0 and society 5.0. In *5th International Conference on Education and Technology (ICET 2019)* (pp. 565-570). Atlantis Press.

Ikenga, G. U., & van der Sijde, P. (2024). Twenty-first century competencies; about competencies for industry 5.0 and the opportunities for emerging economies. *Sustainability*, *16*(16), 7166.

Implementation of the Realistic Mathematics Education (RME) Approach in Geometry Learning in Secondary Schools. (2024). *Aksioma Education Journal*, *1*(3), 17-30. https://doi.org/10.62872/rgn3w339

Jaedun, A., Nurtanto, M., Mutohhari, F., Saputro, I. N., & Kholifah, N. (2024). Perceptions of vocational school students and teachers on the development of interpersonal skills towards Industry 5.0. *Cogent Education*, *11*(1), 2375184.

Meifinda, Y., & Nabela, S. J. (2023). The Challanges In Implementing Thematic Learning Based On Scientific Approach At Elementary School In The Industrial Revolution 5.0. *Elementary School Journal PGSD FIP Unimed*, *13*(1), 9-15.

Mytra, P., Wardawaty, A., & Kusnadi, R. (2021, September). Society 5.0 in education: Higher order thinking skills. In *BIS-HSS 2020: Proceedings of the 2nd Borobudur International Symposium on Humanities and Social Sciences, BIS-HSS 2020, 18 November 2020, Magelang, Central Java, Indonesia* (Vol. 242). European Alliance for Innovation.

Pahmi, S., Juandi, D., & Sugiarni, R. (2022). The effect of STEAM in mathematics learning on 21st century skills: A systematic literature reviews. *Prisma*, *11*(1), 93-104.

Purwanto, M. B., Hartono, R., & Wahyuni, S. (2023). Essential skills challenges for the 21st century graduates: Creating a generation of high-level competence in the industrial revolution 4.0 era. *Asian Journal of Applied Education (AJAE)*, *2*(3), 279-292.

Ramadhani, D., Kenedi, A. K., Helsa, Y., Handrianto, C., & Wardana, M. R. (2021). Mapping higher order thinking skills of prospective primary school teachers in facing society 5.0. *Al Ibtida: Jurnal Pendidikan Guru MI*, *8*(2), 178-190.

Rochmat, C. S., Yoranita, A. S. P. Y., Prihatini, M., & Wibawa, B. A. (2023). The Quality of Education from Islamic Perspective Analysis of The Merdeka Belajar Curriculum in Facing The Society 5.0 Era. *Jurnal Tarbiyatuna*, *14*(1), 75-93.

Sajidan, S., Suranto, S., Atmojo, I. R. W., Saputri, D. Y., & Etviana, R. (2022). Problem-based learning-collaboration (PBL-C) model in elementary school science learning in the industrial revolution era 4.0 and Indonesia society 5.0. *Jurnal Pendidikan IPA Indonesia*, *11*(3), 477-488.

Siahaan, E. Y. S., Muhammad, I., Dasari, D., & Maharani, S. (2023). Research on critical thinking of pre-service mathematics education teachers in Indonesia (2015-2023): A bibliometric review. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*, *9*(1), 34-50.

Sunarto, M. J., & Hariadi, B. (2022). C-CHIL: A New Learning Model for Advanced Mathematics Course in The Society 5.0 Era. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(3), 1789-1804.

Supendi, A., & Nurjanah, N. (2020, March). Society 5.0: Is it high-order thinking?. In *International Conference on Elementary Education* (Vol. 2, No. 1, pp. 1054-1059).

Supriatna, D., & Baharuddin, M. (2024). Transforming Education in the Age of Society 5.0: Exploring the Relationship Between Technological Pedagogical Knowledge and Adaptation Skills in Designing Learning. In *International Conference on Actual Islamic Studies* (Vol. 3, No. 1).

Tavares, M. C., Azevedo, G., & Marques, R. P. (2022). The challenges and opportunities of era 5.0 for a more humanistic and sustainable society—a literature review. *Societies*, *12*(6), 149.

The Effectiveness of Mathematics Learning with the STEAM Approach in Improving Students' Critical Thinking Skills. (2024). *Aksioma Education Journal*, *1*(3), 1-16. https://doi.org/10.62872/kdepgn33

Ungureanu, A. V. (2020, August). The transition from industry 4.0 to industry 5.0. The 4Cs of the global economic change. In *16th Economic International Conference NCOE 4.0 2020* (pp. 70-81). Editura Lumen, Asociatia Lumen.

Wulandani, C., Putri, M. A., Pratiwi, R. I., & Sulong, K. (2022). Implementing project-based steam instructional approach in early childhood education in 5.0 industrial revolution era. *Indonesian Journal of Early Childhood Educational Research*, *1*(1), 29-37.