

Enhancing Vocational Students Critical Thinking Skill on Math Logic

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Abstract

This study aims to analyze differences in the critical thinking skills of vocational high school (SMK) students who study using problem-based learning (PBL)-based modules and school textbooks and vocational students who study using conventional methods assisted by school textbooks. This research is a quasi-experiment research. The research subjects were 76 students at one of the Vocational Schools in Mataram City. The instruments used were tests of critical thinking skills and interview guidelines. The critical thinking ability indicators used combine the critical thinking ability indicators from Ennis and Facione, namely explaining the answer with appropriate reason, justify the quality of argument, justify the relevancy of data and asking appropriate question. The data from the critical thinking skills test were tested using the T-test and the Mann Whitney U-test. The results of this study are 1) there are differences in critical thinking skills between vocational students who study using PBL-based modules and school textbooks and vocational students who learn using conventional methods assisted by school textbooks, 2) there are differences in critical thinking abilities in explaining the answer with appropriate reason and asking appropriate question between SMK students who study using PBL-based modules and school textbooks and SMK students who study using conventional methods assisted by school textbooks.

Keywords: critical thinking; problem-based learning; module; vocational school

Abstrak

Penelitian ini bertujuan untuk menganalisis perbedaan kemampuan berpikir kritis siswa Sekolah Menengah Kejuruan (SMK) yang pembelajarannya menggunakan modul berbasis *problem-based learning* (PBL) dan buku teks sekolah dengan siswa SMK yang pembelajarannya menggunakan metode konvensional berbantuan buku teks sekolah. Penelitian ini merupakan penelitian eksperimen semu. Subjek penelitian adalah siswa di salah satu Sekolah Kejuruan di Kota Mataram yang berjumlah 76 orang. Instrumen yang digunakan adalah tes kemampuan berpikir kritis dan pedoman wawancara. Indikator kemampuan berpikir kritis yang digunakan menggabungkan indikator kemampuan berpikir kritis dari Ennis dan Facione yaitu menjelaskan jawaban dengan alasan yang tepat, membenarkan kualitas argumen, membenarkan relevansi data dan mengajukan pertanyaan yang tepat. Data hasil tes kemampuan berpikir kritis diuji menggunakan uji-t dan uji-U Mann Whitney. Hasil penelitian ini adalah 1) terdapat perbedaan kemampuan berpikir kritis antara siswa SMK yang pembelajarannya menggunakan modul berbasis PBL berbantuan buku teks sekolah dengan siswa SMK yang pembelajarannya menggunakan metode konvensional berbantuan buku teks sekolah, 2) terdapat perbedaan kemampuan berpikir kritis dalam menjelaskan jawaban dengan alasan yang tepat dan mengajukan pertanyaan yang tepat antara siswa SMK yang pembelajarannya menggunakan modul berbasis PBL berbantuan buku teks sekolah dengan siswa SMK yang pembelajarannya menggunakan metode konvensional berbantuan buku teks sekolah.

Kata Kunci: berpikir kritis; pembelajaran berbasis masalah; modul; sekolah menengah kejuruan (SMK)

1. INTRODUCTION

Critical thinking becomes one of the skills needed in 21st century (Khoiri et al., 2021). In general, critical thinking makes someone become accurate in analyzing and good thinker (Ramdani et al., 2021). Similarly, critical thinking skill in mathematics helps someone to formulating the hypothesis, thinking about another alternative ways to solve problem and planning the investigation (Ennis, 1993). This skill needed to be mastered for all student, including vocational student.

Vocational student study about theory and practice skill which they needed in the expertise area (Dewanto et al., 2018). The student who graduates from this school are expected to be ready to enter the labour market. In the professionalism work, critical thinking become one of the important skills (Changwong et al., 2018). Employee who had been in competitive working environment also agree that graduates need to have good critical thinking skills (Cruz et al., 2020). Good critical thinkers are able to interpret, analyze, evaluate and make a good decision about work (Selviana et al., 2016).

Critical thinking skill can be improved through the learning process in class. The success of this improvement affected by several factors, namely learning design and teaching material. One of the learning design which empower critical thinking skill is Problem Based Learning (PBL) (Kertiyani et al., 2022; Liu & Pásztor, 2022; Sholihah & Lastariwati, 2020). On the other hand, previous study found that teaching material such as module help student to enhance their critical thinking skill (Serevina & Sari, 2018; Seruni et al., 2020), especially in vocational school (Baidowi et al., 2023; Kusumaningrum & Wijayanto, 2020; Nurul Iskandar et al., 2021). Astuti stated that PBL will run best if the book or the module used in learning process meet the syntax of PBL (Astuti et al., 2019).

Most vocational school in Indonesia use textbook from some publisher or government to study about mathematics. Unfortunately, some teachers require another source which more effective and practical to vocational school student (Maharani et al., 2019). This additional source is allowed because Merdeka curriculum also. To meet the need of teacher and the need to improve vocational student critical thinking, this study aims to analyze the effect of problem-based learning module to enhance critical thinking skill of vocational student.

Futhermore, research indicates that students in vocational high schools (SMK) often face difficulties in learning mathematical logic. Common challenges include determining the equivalence of compound sentences, drawing conclusions from premises, and determining truth values of compound sentences (Mirati, 2015). Students' lack of attention when reading questions, insufficient understanding of mathematical logic concepts, and inadequate practice with logic problems contribute to their struggles (Sawitri, 2020).

To address these issues, we focused the critical thinking improvement on Math Logic topic. The research questions of this study are:

- 1) Is there the difference between critical thinking skill of vocational student who learn using PBL module and textbook than the vocational student who learn using conventional method and textbook on Math Logic topic?
- 2) Is there the difference between critical thinking skill of vocational student who learn using PBL module and textbook than the vocational student who learn using conventional method and textbook in each critical thinking indicator on Math Logic topic?

2. RESEARCH METHOD

This research was quasi experiment research. The subject of this research was XI vocational school in Mataram City. The subject was divided into the experiment class and control class. The experiment class consisted of 35 students who learn using PBL module on Math Logic topic and text book. Meanwhile, there were 31 students in control class who learn using conventional method and assisted with text book. The mathematics topic used in this research is mathematic logic which consist of conjunction, disjunction, negation, inferences, quantor.

The instrument used in this research is critical thinking test and interviews guidelines. Critical thinking test consisted of the data from the indicator of critical thinking. There are several indicators proposed from some researcher. Ennis stated that someone categorized, such as judge the quality of argument including the relevancy of data and ask appropriate question (Ennis, 1993). On the other hand, Facione offered critical thinking indicator as interpretation, analysis, evaluation, conclusions, explanation and self-regulation (Facione, 2015). This study used the critical thinking indicator adopted from Ennis and Facione, namely concluding the result with supportive evidence, explaining the answer with appropriate reason, justify the quality of argument, justify the relevancy of data and asking appropriate question. The critical thinking test consists of five questions. Table 1 below present the distribution of the sub material and the indicator in each question.

Table 1. The Distribution of The Sub Material and The Indicator in Each Question

Question Number	Critical Thinking Indicator	Subtopic
1	Concluding the result with supportive evidence	Disjunction and conjunction
2	Justify the quality of argument	Negation
3	Explaining the answer with appropriate reason	Implication
4	Justify the relevancy of data	Quantor
5	Asking appropriate question	Inferences

Meanwhile, the interviews used in this study are unstructured interviews that are open to confirm and reveal things that are not visible in the writings/answers of students on the critical thinking ability test and explore students' and teacher opinions about the module and learning model used in class.

The data obtained from this study are the student answer from critical thinking test and interview. The student answer from critical thinking test was analyzed using inferential test. T test used to analyze the data if the data met the assumption of normality and homogeneity. Otherwise, the non-parametric test U-Mann Whitney used to analyze if the assumption did not meet.

3. RESULT AND DISCUSSION

3.1 Research Question 1: The difference between critical thinking skill of vocational student who learn using PBL module and textbook than the vocational student who learn using conventional method and textbook on Math Logic topic

To answer the research question number 1, we examined the normality of total score of critical thinking test from experiment class and control class. Tabel 2 presents the result of normality test.

Table 2. The Result of Normality Test of Experiment and Control Class

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Total_PBL	.168	31	.026	.943	31	.100
Total_Konvensional	.109	31	.200*	.937	31	.070

According to Table 2, the sig of total score PBL and conventional, respectively 0.100 and 0.07. Those sig are more than 0.05, therefore H_0 accepted. It indicates that the data came from the normally distributed population. Because the data met the requirement of normally distributed, we can use T-test to continue the test. Table 3 show the result of T test.

Table 3. The T-test Result

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Total_PBL_Konvensional_UjiT	Equal variances assumed	3.922	64	.000	10.85530	2.76813	5.32533	16.38527
	Equal variances	3.858	55.8	.000	10.85530	2.81345	5.21891	16.49169

not
assumed

Table 3 shows that the sig 2-tailed with the assumption of variances equal and not equal are $0.000 < 0.05$. It means H_0 is rejected. We can conclude that the critical thinking skill of vocational student who learn using PBL module on Math Logic and textbook are difference with the vocational student who learn using conventional method and textbook.

The statistics of the critical thinking ability of vocational student who learn using PBL module and textbook and the vocational student who learn using conventional method and textbook are presented in Table 4.

Table 4. The Statistics of Critical Thinking Ability of Experiment and Control Class

	Kelompok	N	Mean	Std. Deviation	Std. Error Mean
Total_PBL_Konvensional_UjiT	PBL	35	53.3714	9.71078	1.64142
	Konvensional	31	42.5161	12.72235	2.28500

Table 3 show that the mean of PBL class is 53.3714 and the mean of conventional class is 42,5161. It is indicated that the critical thinking of experiment class is higher than the control class.

There are several reasons that make the critical thinking of experiment class is higher than the control class. The characteristics of PBL which try to solve the problem to build the concept allow student critically think the answer of the problem. From the interview conducted with the teacher teaching in experiment class found that PBL are able to accommodate the need of vocational student to build the concept from the problem around their daily activity. Because the problem related to their life, student tend to understand the problem easily. It makes the process to solve the problem become more joyful. Furthermore, the discussion in group allowed student to collaboratively answer the problem, which become on of the learning process that suitable to student in 21st century (Andone & Frydenberg, 2014). Moreover, the discussion facilitate student to answer the question from their teammate, so it can help student to improve their critical thinking indicator ability in explaining the answer with appropriate reasoning and asking appropriate question (Nurbaiti et al., 2021; Wiliawanto et al., 2019).

3.2 Research Question 2: The difference between critical thinking skill of vocational student who learn using PBL module and textbook than the vocational student who learn using conventional method and textbook in each critical thinking indicator on Math Logic topic

To answer the research question number 2, we examined the normality of score of critical thinking test from experiment class and control class in each question in critical thinking test. Tabel 1 presents the result of normality test.

Table 5. The Result of Normality Test of in Each Question

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Soal_1_PBL	.368	31	.000	.721	31	.000
Soal_2_PBL	.530	31	.000	.340	31	.000
Soal_3_PBL	.457	31	.000	.457	31	.000
Soal_4_PBL	.265	31	.000	.710	31	.000
Soal_5_PBL	.380	31	.000	.756	31	.000
Soal_1_Konvensional	.384	31	.000	.723	31	.000
Soal_2_Konvensional	.299	31	.000	.668	31	.000
Soal_3_Konvensional	.196	31	.004	.907	31	.011
Soal_4_Konvensional	.170	31	.023	.919	31	.023
Soal_5_Konvensional	.197	31	.004	.902	31	.008

According to Table 5, the sig. of critical thinking in each indicator are less than 0.05, therefore H_0 rejected. It means, the data do not come from the normally distributed population. Because the data do not meet the requirement of normally distributed, we use U-Mann Whitney to continue the test. Table 6 shows the result of U-Mann Whitney test.

Table 6. The U-Mann Whitney Test Result in Each Question

Question Number	Critical Thinking Indicator	Subtopic	Sig	Result	Interpretation
1	Concluding the result with supportive evidence	Disjunction and conjunction	0.950	H_0 accepted	There is no difference of explaining the answer with appropriate reason ability between experiment and control class
2	Justify the quality of argument	Negation	0.000	H_0 rejected	There is difference of justify the quality of argument ability between experiment and control class
3	Explaining the answer with appropriate reason	Implication	0.236	H_0 accepted	There is no difference of explaining the answer with appropriate reason ability between experiment and control class
4	Justify the relevancy of data	Quantor	0.299	H_0 accepted	There is no difference of justify the relevancy of data ability between experiment and control class
5	Asking appropriate question	Inferences	0.005	H_0 rejected	There is difference of asking appropriate question ability

Question Number	Critical Thinking Indicator	Subtopic	Sig	Result	Interpretation
					between experiment and control class

According to Table 6, there is no difference ability between experiment and control class in three indicators, namely concluding the result with supportive evidence, explaining the answer with appropriate reason and justify the relevancy of the data. An interview with a student showed that they sometimes struggle to apply logical rules when drawing conclusions, especially when the problem feels relevant to their own experiences. For example, in the first problem, which was related to their classroom life, they tended to consider different perspectives instead of following formal logic rules like disjunction and conjunction. This suggests that when a problem feels personal, students may rely more on intuition rather than strict logical reasoning (Gette et al., 2018).

Meanwhile there is a difference ability in indicator justify the quality of argument and asking appropriate question. Table 7 show the statistics score in indicator justify the quality of argument and asking appropriate question.

Table 7. The statistics Score in Indicator to Justify the Quality of Argument and Asking Appropriate Question

Indicator	Group	N	Mean
Justify the quality of argument	PBL	35	9.3226
	Konvensional	31	4.5161
Asking appropriate question	PBL	35	5.5161
	Konvensional	31	2.4194

The maximum mean score of each indicator is 10. According to Table 7, the mean of PBL class (the experiment class) is higher than the conventional (the control class). It means the ability to justify the quality of argument and asking appropriate question of vocational student who learn using PBL module and textbook is higher the vocational student who learn using conventional method and textbook in those indicators.

The findings of this study are the ability to justify the quality of argument and asking appropriate question of vocational student who learn using PBL module and textbook is higher the vocational student who learn using conventional method and textbook in those indicators. It causes by several factors. PBL enhance the problem posing ability of student (Kertiyani et al., 2022). When try to solve the problem on PBL, student will ask about various situation to solve the problem. It allows student to improve their problem posing ability to ask relevance question and also their ability to justify the argument. According

to the interview with teacher who teach the experiment class, through many problems, students show their curiosity that raises many questions in solving problems (Maharani et al., 2019). Similarly, the interview conducted with student show that student had the curiosity in solving the problem given because the problems are relevant to the student life. The question aroused in learning process because the material and the question related to the daily life.

4. CONCLUSION

The conclusions of this research is the critical thinking skill of vocational student who learn using PBL module and textbook are difference with the vocational student who learn using conventional method and textbook. The differences are ability in indicator justify the quality of argument and asking appropriate question. Meanwhile, there is no difference ability between vocational student who learn using PBL module and textbook with the vocational student who learn using conventional method in three indicators, namely explaining the answer with appropriate reason and justify the relevancy of the data. Meanwhile there is a difference.

5. REKOMENDATION

In this study, we employed a combination of critical thinking indicators proposed by Ennis and Facione to assess student's critical thinking skill. While this approach provided valuable insights, it is important to acknowledge that various scholars have developed alternative frameworks for evaluating critical thinking abilities. Consequently, future research may benefit from exploring the impact of problem-based learning (PBL) on critical thinking skills using indicators established by other experts.

7. REFERENCES

- Andone, D., & Frydenberg, M. (2014). Developing digital literacy skills through interactive images, multimedia mashups, and global groups. *Proceedings - IEEE 14th International Conference on Advanced Learning Technologies, ICALT 2014*, 632–633. <https://doi.org/10.1109/ICALT.2014.184>
- Astuti, A. P., Aziz, A., Sumarti, S. S., & Bharati, D. A. L. (2019). Preparing 21st Century Teachers: Implementation of 4C Character's Pre-Service Teacher through Teaching Practice. *Journal of Physics: Conference Series*, 1233(1). <https://doi.org/10.1088/1742-6596/1233/1/012109>
- Baidowi, Arjudin, Novitasari, D., & Kertiyani, N. M. I. (2023). The Development of Project Based Learning Module for Vocational High Schools to Improve Critical Thinking Skills. *JTAM*, 7(1), 217–230. <https://doi.org/10.31764/jtam.v7i1.11806>
- Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, 11(2), 37–48. <https://doi.org/10.14254/2071>
- Cruz, G., Payan-Carreira, R., Dominguez, C., Silva, H., & Morais, F. (2020). *What critical thinking skills and dispositions do new graduates need for professional life? Views*

- from Portuguese employers in different fields.
<https://doi.org/10.1080/07294360.2020.1785401>
- Dewanto, W. K., Agustianto, K., & Sari, B. E. (2018). Developing thinking skill system for modelling creative thinking and critical thinking of vocational high school student. *Journal of Physics: Conference Series*, 953(1). <https://doi.org/10.1088/1742-6596/953/1/012115>
- Ennis, R. H. (1993). Critical thinking assessment. *Theory Into Practice*, 32(3), 179–186. <https://doi.org/10.1080/00405849309543594>
- Facione, P. A. (2015). *Permission to Reprint for Non-Commercial Uses Critical Thinking: What It Is and Why It Counts*. Peter A. Facione, Measured Reasons LLC.
- Gette, C. R., Kryjevskaja, M., Stetzer, M. R., & Heron, P. R. L. (2018). Probing student reasoning approaches through the lens of dual-process theories: A case study in buoyancy. *Physical Review Physics Education Research*, 14(1). <https://doi.org/10.1103/PhysRevPhysEducRes.14.010113>
- Kertiyani, N. M. I., Fatimah, S., & Dahlan, J. A. (2022). Critical thinking skill through problem-based learning with problem posing within-solution. *Journal of Mathematics and Science Teacher*, 2(2), em017. <https://doi.org/10.29333/mathsciteacher/12369>
- Khoiri, A., Evalina, Komariah, N., Utami, R. T., Paramarta, V., Siswandi, Janudin, & Sunarsi, D. (2021). 4Cs Analysis of 21st Century Skills-Based School Areas. *Journal of Physics: Conference Series*, 1764(1). <https://doi.org/10.1088/1742-6596/1764/1/012142>
- Kusumaningrum, B., & Wijayanto, Z. (2020). Apakah Pembelajaran Matematika Secara Daring Efektif? (Studi Kasus pada Pembelajaran Selama Masa Pandemi Covid-19). *Kreano, Jurnal Matematika Kreatif-Inovatif*, 11(2), 136–142. <https://doi.org/10.15294/kreano.v11i2.25029>
- Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, 45. <https://doi.org/10.1016/j.tsc.2022.101069>
- Maharani, A., Darhim, Sabandar, J., & Herman, T. (2019). PBL-team teaching on developing vocational mathematics textbook. *Journal of Physics: Conference Series*, 1280(4). <https://doi.org/10.1088/1742-6596/1280/4/042007>
- Mirati, L. (2015). Analisis Kesulitan Belajar Matematika Pada Topik Logika Pada Siswa SMK Muhammadiyah 3 Klaten Utara. *Jurnal Pendidikan Matematika*, 2(1), 25–40.
- Nurbaiti, Meriyati, & Putra, F. G. (2021). Pengaruh Model Pembelajaran Teams Games Tournament Berbantuan Konsep Gamifikasi Terhadap Kemampuan Berpikir Kritis Matematis. *Nabla Dewantara: Jurnal Pendidikan Matematika*, 6(1), 1–13.
- Nurul Iskandar, Mustaji, Miftakhul Jannah, & Soetam Rizky Wicaksono. (2021). The Problem Based Learning in Enhancing Students' Critical Thinking for Reading Skills in English Teaching at Vocational School. *IJORER: International Journal of Recent Educational Research*, 2(2), 237–249. <https://doi.org/10.46245/ijorer.v2i2.93>
- Ramdani, S. D., El Islami, R. A. Z., Pratiwi, H., Fawaid, M., Abizar, H., & Maulani, I. (2021). Developing digital teaching material on Basic Electricity based on problem-based learning in vocational education. *Jurnal Pendidikan Vokasi*, 11(1). <https://doi.org/10.21831/jpv.v11i1.38894>
- Sawitri, W. Y. (2020). Analisis Kesalahan Siswa SMK Kelas XI Pada Materi Logika Matematika. *Sigma*, 5(2), 37–43.

- Selviana, V., As'ari, A. R., & Muksar, M. (2016). Kemampuan Berpikir Kritis Siswa SMK dalam Menyelesaikan Masalah Kombinatorika dan Peluang. *Seminar PPG-3T UM, January 2016*, 529–535.
- Serevina, V., & Sari, I. J. (2018). Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student's Science Process Skill. *TOJET: The Turkish Online Journal of Educational Technology*, 17(3).
- Seruni, R., Munawaroh, S., Kurniadewi, F., & Nurjayadi, M. (2020). Implementation of e-module flip PDF professional to improve students' critical thinking skills through problem based learning. *Journal of Physics: Conference Series*, 1521(4). <https://doi.org/10.1088/1742-6596/1521/4/042085>
- Sholihah, T. M., & Lastariwati, B. (2020). Problem based learning to increase competence of critical thinking and problem solving. *Journal of Education and Learning (EduLearn)*, 14(1), 148–154. <https://doi.org/10.11591/edulearn.v14i1.13772>
- Wiliawanto, W., Bernard, M., Akbar, P., Ikin Sugandi, A., Siliwangi, I., Terusan Jendral Sudirman, J., tengah, C., Cimahi, K., & Barat, J. (2019). *Penerapan Strategi Pembelajaran Aktif Question Student Have Untuk Meningkatkan Kemampuan Berpikir Kritis Matematik Siswa SMK*. 3(1), 136–145.