

Research Article

Mathematical critical thinking ability through Brain based learning model in view of self-regulated learning

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Received: 20 March 2023

Revised: 27 April 2023

Accepted: 24 May 2023

Available online: 30 June 2023

ABSTRACT

The method used is quantitative with a quasi-experimental design. Data collection techniques using tests and questionnaires. Data analysis techniques by testing the increase in mathematical critical thinking skills and learning independence. The results showed that there were 23 students in the control class with a moderately critical category with a percentage of 71.875%. The critical category consists of 9 students with a percentage of 28.125%. In the experimental class there are 3 students in the critical category with a percentage of 9.375%. For the very critical category there are 29 students with a percentage of 90.625%. The results of the t test show that the P-value is $0.000 < 0.05$, there is an increase in the ability to think critically mathematically through the brain based learning model. The results of the control class self-regulated learning were 5108 with a mean value of 63.85 in the fairly independent category. The experimental class is 6114 with an average value of 76.43 in the independent category. Test results with the t test show a P-value of $0.000 < 0.05$, meaning that the class has independent learning in the experimental class.

Keywords: mathematical critical thinking; brain-based learning model; self-regulated learning;

1. INTRODUCTION

Advances in science and technology have become a driving force in the world of education to innovate from various aspects, both in terms of processes and educational processes. The current 21st century emphasizes cognitive, affective and psychomotor and demands the world of education to be competent in thinking skills. The ability to think is a person's ability that is needed in life. These thinking skills include critical thinking skills (Cahyana, et al 2017), think creatively according to procedure (Wahyuni & Pasaribu, 2022), Think logically if you get a problem (Rosmauli & Watini, 2022), and the ability to solve problems by simplifying them (Zahroh et al, 2020). The ability to think is one of the thinking abilities that a person has to solve problems in everyday life in dealing with society and each individual. The ability to think critically can also generate high curiosity, if applying this abilities it can solve the problems being faced. Critical thinking skills are needed in order to deal with the rapid flow of information. The habit of critical thinking causes a person to choose important information, to conclude events with his own logic.

There are several opinions about critical thinking skills, one of which is according to Facione (2011) says that critical thinking is a process in self-regulation to decide, analyze and evaluate it is also useful to present opinions along with complete evidence. Tari & Rosana, (2019) revealed that the ability to think critically is a high-level ability to use cognitive skills to process and process the information obtained. Heard et al, (2020) added that mathematical critical thinking is a person's ability to think in reflecting and focusing on what is believed or done. Alfonso (2015) says that critical thinking ability is a high-level thinking process that is useful for combining information to solve a problem. Mathematical critical thinking ability is influenced by cognitive factors (Lestari et al, 2019), affective factor (Saputri et al, 2020), psychomotor factors (Puspitasari et al, 2021). Cognitive factors in Bloom's taxonomy revised by Anderson and Krathwohl which lead to higher order thinking. 6 cognitive aspects which are part of higher-level thinking, namely knowledge (C1), understanding (C2), application (C3) analyzing (C4), evaluating, (C5) and creating (C6) (Abidin & Tohir, 2019). affective aspects related to positive emotions and personality in students (Alifah, 2019). psychomotor aspects related to movement behavior or physical coordination of students (Rahman, 2020).

There are problems experienced by students in critical thinking mathematically, one of which is that they are still unable to understand the concept of their own lesson. If the teacher asks to identify these problems, they cannot answer according to the procedure. Students are still not able to analyze difficult problems into simpler ones, also are still confused in solving problems, especially in making conclusions and evaluating the conclusions that have been obtained. Based on the results of student tests with a total of 5 questions, only 2 were answered by 3 students even though the total number of

students participating was 32. this indicates that the ability to think critically mathematically is still low. based on information from students that the teacher's method in the process of learning activities is boring, takes more notes than makes students active. During the daily test, some students cheat or wait for their friends to finish and then work on the questions given by the teacher. It cannot be said that students have met the indicators of critical thinking skills, namely (1) being able to provide simpler explanations, (2) being able to give appropriate reasons according to procedures, (3) being able to draw conclusions correctly, (4) being able to explain conclusions that has been obtained, (5) able to be able to evaluate the problem (Setiana & Purwoko, 2021). Indicators of mathematical critical thinking skills include (1) being able to interpret problems, (2) being able to analyze solutions to problems, (3) being able to evaluate problems (4) being able to draw conclusions along with evidence (Seventika et al, 2018). Ennis (2011) states that there are 6 indicators of mathematical critical thinking skills, namely focus, reason, inference, situation, clarity and overview (Kristihana & Ratu, 2018).

Critical thinking ability is a high-level thinking ability related to affective aspects (Asfiah, 2021). These aspects include learning independence is an activity that occurs on individual encouragement (Wong et al 2019), acquire knowledge without depending on others (Jannah et al, 2021), process in building oneself to develop knowledge (Oates, 2019), confident that there is the ability to achieve achievement in learning (Adl & Alkharusi, 2020), self-discipline to form a better character (Latipah et al, 2021), a sense of responsibility for the tasks assigned by the teacher are done and collected on time (Alabidi et al, 2022), High motivation will create curiosity in new knowledge and encourage success in learning (Pelikan et al, 2021), can control themselves so that they can solve problems related to colleagues (Granberg et al, 2021). Some indicators of self-regulated learning include according to Schunk & Zimmerman (1998) being able to make their own study schedule, being able to monitor learning progress while implementing a design, being able to evaluate learning outcomes completely, and being able to reflect (Kusuma, 2020). according to Hendriana et al (2017) indicators of self-regulated learning include not depending on others, having self-confidence, having a disciplined attitude, having high self-motivation, having a sense of responsibility, and being able to control yourself (Ansori & Herdiman, 2019).

The results of interviews with teachers related to the independence of learning in students that the students' self-confidence was still low when given assignments, there were still many students who copied their peers, could not argue, they were still afraid if asked to come forward to give explanations regarding answers. Also on the lack of discipline in students because there are still many who come late to school. when given assignments by the teacher, many students did not collect them on time, the aspect of responsibility for students was low, many students could not make their own study schedules or set learning goals. For high motivation in students it is still low, it is proven that during the student learning process, many students tell stories with their classmates. The low self-control of students is evident when they are given the task of discussing instead debating and students' answers are not in accordance with proper procedures.

The low ability to think critically mathematically and independent learning is caused by an inappropriate learning model. Therefore, researchers will apply a learning model that makes students active (Shabatat & Tarawneh, 2016), fun learning process (Kartikaningtyas et al, 2018), and challenge students to think (Balushi & Balushi, 2018). The learning model is brain-based learning, namely a learning model that emphasizes the brain to think without pressure (Putri et al, 2019). This learning model is the development of neuroscience (Prasetya et al, 2022), developed by Paul McClain in 1970 (Nurasiah et al, 2022). With the steps of 1) pre-exposure, 2) preparation, 3) initiation and acquisition, 4) elaboration, 5) incubation and memory formation, 6) belief verification and checking, and 7) celebration and integration (Rulyansah & Hasanah, 2018). When students have high mathematical critical thinking, there is high self-regulated learning in line with research from Prihatini et al, (2020) which reveals that self-confident, disciplined, responsible, and with high motivation and self-control, the ability to think critically automatically high student mathematics. If students have high self-regulated learning then high students' mathematical critical thinking skills are in line with research (Kusmaharti, 2022) which reveals that if students have a sense of trust, discipline, responsibility, have high motivation and have self-control then there is a high ability to think mathematically critically. There is also an increase in the ability to think critically mathematically when treated with a brain-based learning learning model with its strategy, namely with the strategies and steps of the learning model. This is in line with the research of Mulia et al, (2021) that the brain-based learning model can improve students' mathematical critical thinking skills rather than using conventional approaches.

2. RESEARCH METHOD

The population of this study consisted of 100 class X students of Tegal City Dynamics Vocational School consisting of 4 majors, namely automotive engineering, machining engineering, software engineering and electrical engineering. In this study the sampling technique was simple random sampling, meaning that sample members were taken randomly from the population without regard to population strata and each population could be selected. (Ghayab et al, 2016). For research, two classes were taken, one control class and the other an experimental class with 32 students each. The control class uses a conventional approach and the experimental class uses a brain-based learning model. The research procedure consisted of several stages, namely the initial stage of the research by distributing tests of mathematical critical thinking skills to find out the students' initial data. The second stage is conducting research by giving treatment to respondents. The third stage is analyzing research data using the t test. The fourth stage of the research report. These stages are for mathematical

critical thinking skills. For independent learning by dividing the questionnaire on the scale of independence.

In this study, the data that had been collected through post-tests given to students were then analyzed. The pretest was carried out before the study with the aim of identifying students' initial skills as well as a basis for heterogeneous grouping in learning. The post-test was carried out after the research ended with the aim of measuring the increase in mathematical critical thinking skills. The pre-test and post-test questions on mathematical critical thinking skills consist of 6 questions with each indicator being one question in the form of an essay. Questionnaires in research are used to measure the increase in learning independence. The questionnaire consists of 50 questions with details of 25 positive questionnaires and 25 negative questionnaires. Questionnaires were distributed after the learning was finished. The results obtained from student learning are analyzed using descriptive statistics which aim to determine descriptively students' understanding of mathematical material after applying the brain-based learning model. In the category below to determine the increase in mathematical critical thinking skills and learning independence in students of Tegal City Dynamics Vocational School.

Table 1. Categories of Increasing Mathematical Critical Thinking Skills

Category	Interpretation
81.25 – 100	Very Critical
62.50 – 81.24	Critical
42.75 – 62.49	Pretty Critical
25.00 – 42.74	Less Critical

Source:(Haryanti, et al 2019)

Table 2. Categories of self-regulated learning Improvement

Category	Interpretation
86 – 100	Very Independent
76 – 85	Independent
60 – 75	Self sufficient
55 – 59	Less Independent
0 – 54	Not Independent

Statistical descriptive analysis of mathematical critical thinking skills is used to calculate student learning outcomes. Data taken from the pre-test and post-test were analyzed with the aim of obtaining an increase in mathematical critical thinking skills. While the independent learning is taken from the value of the independent learning questionnaire in the control class and the experimental class.

3. RESULTS AND DISCUSSION

3.1 Results

a. Analysis of Mathematical Critical Thinking Ability

Research on brain-based learning learning models to improve critical thinking skills is taken from the pre-test and post-test values of the control class and the experimental class. To find out these results, start with a statistical description which aims to describe the data in the study (Maysani & Pujiastuti, 2020).

Table 3. Categories of Mathematical Critical Thinking Control Class and Experimental Class

Description		Pretest				Posttest			
		Control Class		Experiment Class		Control Class		Experiment Class	
Category	Score	f	%	f	%	f	%	f	%
Very Critical	25 -42.75	0	0	0	0	0	0	0	0
Critical	42.76 -62.50	25	78.125	30	93.75	23	71.875	0	0
Pretty Critical	62.51- 81.25	7	21.875	2	6.25	9	28.125	3	9.375
Less Critical	81.26 – 100	0	0	0	0	0	0	29	90.625
Amount		32	100	32	100	32	100	32	100

Meanwhile, in each indicator of the ability to think critically mathematically with indicators, understanding concepts, identifying problems, analyzing problems, solving problems, making conclusions and evaluating. To find out the initial abilities of students taken from the high, medium and low categories can be seen in the **Table 4**.

Table 4. The results of each category of indicators of Mathematical Critical Thinking

Mathematical Critical Thinking Ability Indicator	Pretest				Posttest			
	Control Class	Category	Experiment Class	Category	Control Class	Category	Experiment Class	Category
Understanding Concepts	80.47	C	80.47	C	85.94	VC	96.09	VC
Identifying Problems	67.97	PC	67.97	PC	68.75	C	89.84	VC
Analyze Problems	60.16	PC	57.81	PC	60.16	PC	82.81	VC
Solve the problem	57.81	PC	56.25	PC	57.81	PC	91.41	VC
Making Conclusions	58.59	PC	54.69	PC	56.25	PC	85.16	VC
Evaluate	47.66	PC	40.63	LC	57.81	PC	67.97	C

Information

VC : Very Critical

C : Critical

PC : Pretty Critical

LC : Less Critical

Normality test

The normality test at the initial and final stages of the study was to determine students' initial and final abilities by using the Shapiro-Wilk in order to know that the data taken as samples were normally distributed.

H₀ : Data of mathematical critical thinking ability is normally distributed.

H₁ : Data on mathematical critical thinking skills are not normally distributed.

Significance value 0.05

Basis for decision making if the P-value ≤ 0.05 then abnormal data H₀ is rejected and H₁ is accepted. If the P-value > 0.05 , then the data is normally distributed, H₀ is accepted and H₁ is rejected.

Table 5. Normality Test Results for Mathematical Critical Thinking

Class	Kolmogorof-Smirnov			Shapiro-Wilk			
	Statistics	Df	Sig	Statistics	Df	Sig	
Early stage	Control Class Pretest	.173	32	.016	.945	32	.102
	Experiment Class Pretest	.143	32	.092	.946	32	.112
Final Stage	Posttest Control Class	.141	32	.109	.937	32	.063
	Experiment Class Posttest	.162	32	.032	.937	32	.062

Based on **Table 5**, it can be seen that in the pretest-posttest the ability to think critically mathematically at a P-value > 0.05 , it can be concluded that the data is normally distributed.

Homogeneity test

Homogeneity test is carried out to find out that the data taken has a homogeneous variant.

H₀: There is no homogeneous variant on the data of mathematical critical thinking ability.

H₁: There is a homogeneous variant on the data of mathematical critical thinking ability.

Significance value 0.05.

Basis for decision making if the P-value ≤ 0.05 then the data does not have a homogeneous variant H₀ is accepted and H₁ is rejected. If the P-value > 0.05 then it has a homogeneous variant, H₀ is rejected and H₁ is accepted.

Table 6. Results of Homogeneity Test of Mathematical Critical Thinking Ability

Levene Statistic	Pretest			Posttest			
	df1	df2	Sig.	Levene Statistic	df1	df2	Sig.
3.075	1	62	.084	1.011	1	62	.318

Based on **Table 6**, it can be seen that the pretest-posttest homogeneity test on mathematical critical thinking skills in both the control class and the experimental class obtained a P-value > 0.05 , having a homogeneous variant.

Mean difference test

Test the difference in the mean of the two classes was carried out to determine whether there is a difference in the mean mathematical critical thinking ability.

H₀ : There is no mean difference between the control class and the experimental class in mathematical critical thinking skills.

H₁ : There is a mean difference between the control class and the experimental class in mathematical critical thinking skills.

Significance value 0.05.

The basis for making decisions in this test is if the P-value ≤ 0.05 then H₀ is rejected and H₁ is accepted. If the P-value > 0.05 H₁ is accepted and H₀ is rejected.

Table 7. Results of Test of Differences in Average Mathematical Critical Thinking Ability

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Initial Results of Mathematical Critical Thinking Ability	Equal variances assumed	3.075	.084	1.222	62	.226	2.46875	2.02068	-1.57054	6.50804
Results of the Final Stage of Mathematical Critical Thinking Ability	Equal variances assumed	1.011	.318	-13.951	62	.000	19.79188	1.41863	22.62768	16.95607

Based on **Table 7**, the mean difference test in the control class pretest and the experimental class got a P-value > 0.05. Then in the final stage, namely the posttest value of the control class which was given conventional treatment and the experimental class which was given the treatment of brain-based learning models, got a P-value < 0.05. So, it can be concluded that there are differences between the control class and the experimental class. This means that the experimental class is better than the control class.

b. Analysis of Self-Regulated Learning

The analysis of learning independence was taken from a questionnaire distributed to the control class and the experimental class. The results of the analysis are in the form of statistical descriptions as follows.

Table 8. Student Questionnaire Results Control Class

Descriptions	Control class	Experiment Class
Total f sum	1600	1600
Score Total	5108	6114
Maximum score	8000	8000
Average (%)	63.85	76.43

Based on table 8 the total score of the positive and negative questionnaires in the control class was 5108 and the mean value of the control class was 63.85. The experimental class got a total score on the positive and negative questionnaires of 6114 with a mean value of 76.43.

Normality test

The normality test on increasing learning independence aims to find out that the data taken from the control and experimental class questionnaire values are normally distributed. The hypothesis in this test is as follows.

H₀: data on increasing self-regulated learning is normally distributed.

H₁: data on increasing self-regulated learning is not normally distributed.

Significance value 0.05.

Basis for decision making if the P-value ≤ 0.05 then abnormal data H_0 is rejected and H_1 is accepted. If the P-value > 0.05 , then the data is normally distributed, H_0 is accepted and H_1 is rejected.

Table 9. Normality test results for increasing self-regulated learning

Class	Kolmogorov-Smirnova			Shapiro-Wilk			
	Statistic	Df	Sig.	Statistic	Df	Sig.	
Self-regulated Learning Questionnaire	Control Class	.146	32	.080	.946	32	.109
	Experiment Class	.110	32	.200*	.963	32	.327

Based on **Table 9**, in the independent learning questionnaire, it can be seen that the P-value is > 0.05 . It can be concluded that the control class and the experimental class are normally distributed.

Homogeneity test

The homogeneity test was carried out to find out that the data taken from the independent learning questionnaire had homogeneous variants. The hypothesis in this test is as follows.

H_0 : there is no homogeneous variant in the self-regulated learning questionnaire data.

H_1 : there is a homogeneous variant in the self-regulated learning questionnaire data.

Significance value 0.05.

Basis for decision making if the P-value ≤ 0.05 then the data does not have a homogeneous variant H_0 is accepted and H_1 is rejected. If the P-value > 0.05 then it has a homogeneous variant, H_0 is rejected and H_1 is accepted.

Table 10. Homogeneity Test Results for Increasing Self-Regulated Learning

Levene Statistic	df1	df2	Sig.
.517	1	62	.475

Based on **Table 10**, it can be seen that the test results get a P-value > 0.05 . then it can be concluded that the data in the questionnaire has a homogeneous variant.

Mean difference test

Test the difference in the mean of the two classes to determine whether there is a difference in the average increase in self-regulated learning in the control class and the experimental class. The test hypothesis is as follows.

H_0 : There is no mean difference between the control class and the experimental class in self-regulated learning.

H_1 : There is a mean difference between the control class and the experimental class in self-regulated learning.

Significance value 0.05.

The basis for making decisions in this test is if the P-value ≤ 0.05 then H_0 is rejected and H_1 is accepted. If the P-value > 0.05 H_0 is accepted and H_1 is rejected.

Table 11. Results of Test of Differences in Mean Self-Regulated Learning

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Self Regulated Learning Questionnaire	Equal variances assumed	.517	.475	-9.757	62	.000	-13.37750	1.37113	-16.11835	-10.63665

Based on **Table 11**, the results of the average test of learning independence in the control class and the self-regulated learning experimental class obtained a P-value of > 0.05 . From these results it can be concluded that there are differences between the control class and the experimental class. This can be interpreted that the experimental class is better than the control class.

3.2 Discussion

Based on the results of the initial stages to find out students' initial abilities in mathematical critical thinking skills there are the same abilities, this is because the selection of research samples uses simple random sampling which allows sampling from populations with strata that do not pay attention to strata. When compared to the control class and the experimental class in the final grades taken from the posttest control class and class there is an increase in mathematical critical thinking skills. the average increase in the experimental class can be seen in the statistical description in table 3. There is an increase in each indicator of students' mathematical critical thinking skills, namely students are very critical in understanding correct concepts, students are very critical in identifying problems given by the teacher. Students are also very critical in analyzing problems when given assignments by the teacher. In analyzing student problems it is very critical, then in solving student problems it is very critical meaning it can solve problems correctly. Students are able to make conclusions in this case students are very critical. Students are able to evaluate the conclusions. It can be said that students in the experimental class are critical.

The increase in mathematical critical thinking skills cannot be separated from the brain-based learning strategy, namely students become more active than before, students can think critically mathematically. When the learning process is given lessons that challenge students to think hard, students can also enjoy lessons, especially mathematics. Then in the stages of the brain-based learning model on elaboration students are given time to explore as much information as possible, at the incubation stage and entering the memory students are given a short break, the last stage students are very happy because there is celebration and integration students are freed to celebrate that the lesson has been finished. From the strategies and stages of the learning model, students can improve their mathematical critical thinking skills. this is in accordance with research submitted by Asfar et al, (2022) that strategies from brain-based learning models can improve the ability to think critically mathematically. The results of Zakaria et al research, (2021) reinforce that the steps of teaching modules that are adapted to the brain-based learning model can improve students' mathematical critical thinking skills.

In self-regulated learning seen from the value of the questionnaire in both classes, namely the control class and the experimental class. There is a significant difference in the control class and the experimental class in self-regulated learning. This difference can be seen in the statistical description that the experimental class is better than the control class. In each indicator of learning independence, namely self-confidence, discipline, high motivation, and self-control which was previously low after being treated with brain-based learning models, it has increased as evidenced by the value of learning independence which can be seen in table 9. This research is reinforced by Nur (2016) that brain-based learning models can enhance self-regulated learning.

4. CONCLUSION

Based on the results of the analysis, it can be found that there is an increase in mathematical critical thinking skills and student learning independence by using the brain based learning model. From the research analysis it can be concluded as follows; **1).** The application of the brain-based learning learning model can make a major contribution to students so that they can solve complex problems into simple ones because this model can awaken students' brains to think more deeply. **2).** The conventional approach is no better than the brain-based learning model that is applied to the experimental class to improve mathematical critical thinking skills. **3).** Using a brain based learning learning model can improve self regulated learning.

ACKNOWLEDGEMENTS

Acknowledgments to the principal of SMK Dinamika Tegal city along with teachers and administrative staff who always support the smooth running of this research.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

REFERENCES

- Abidin, Z., & Tohir, M. (2019). Keterampilan berpikir tingkat tinggi dalam memecahkan deret aritmatika dua dimensi berdasarkan taksonomi bloom. *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika*, 1(1), 44-60.
- Alabidi, S., Owais, A., Alabidi, F., & Taani, O. (2022). Exploring the Role of Reflective Diaries as a Formative Assessment Strategy in Promoting Self-Regulated Learning among ESL Students. *Practical Assessment, Research & Evaluation*, 27, 19.

- Al-Balushi, K. A., & Al-Balushi, S. M. (2018). Effectiveness of Brain-Based Learning for Grade Eight Students' Direct and Postponed Retention in Science. *International Journal of Instruction*, 11(3), 525-538.
- Alfonso, D. V. (2015). Evidence of critical thinking in high school humanities classrooms. *GIST-Education and Learning Research Journal*, (11), 26-44.
- Alifah, F. N. (2019). Pengembangan Strategi Pembelajaran Afektif. *Tadrib*, 5(1), 68-86.
- Ansori, Y., & Herdiman, I. (2019). Pengaruh kemandirian belajar terhadap kemampuan pemecahan masalah matematis siswa SMP. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, 3(1), 11-19.
- Asfar, N. U., Permana, D., Fauzan, A., & Yarman, Y. (2022). Improving Students Mathematical Critical Thinking Ability With Learning Modules Using Brain-Based Learning Models. *Numerical: Jurnal Matematika dan Pendidikan Matematika*, 91-100.
- Asfiah, S. (2021). Implementasi Penilaian Berbasis High Order Thinking Skills dalam Meningkatkan Kemampuan Berpikir Kritis dan Kreatif pada Mata Pelajaran PAI dan Budi Pekerti. *QUALITY*, 9(1), 103-120.
- Cahyana, U., Kadir, A., & Gherardini, M. (2017). Relasi kemampuan berpikir kritis dalam kemampuan literasi sains pada siswa kelas IV sekolah dasar. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, 26(1), 14-22.
- El-Adl, A., & Alkharusi, H. (2020). Relationships between Self-Regulated Learning Strategies, Learning Motivation and Mathematics Achievement. *Cypriot Journal of Educational Sciences*, 15(1), 104-111.
- Febriani, H., & Azizah, U. (2021). Metode Blended Learning Berbantuan Google Classroom Meningkatkan Kemandirian Belajar Siswa. *Jurnal Pendidikan Kimia Indonesia*, 5(1), 9-15.
- Ghayab, H. R. A., Li, Y., Abdulla, S., Diykh, M., & Wan, X. (2016). Classification of epileptic EEG signals based on simple random sampling and sequential feature selection. *Brain informatics*, 3(2), 85-91.
- Granberg, C., Palm, T., & Palmberg, B. (2021). A case study of a formative assessment practice and the effects on students' self-regulated learning. *Studies in Educational Evaluation*, 68, 100955.
- Haryanti, N., Widodo, A. T., & Arfiani, Y. (2019). Penerapan Model Discovery Learning pada Materi Pemanasan Global untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik. *JEMS: Jurnal Edukasi Matematika dan Sains*, 7(2), 55-64.
- Heard, J., Scoular, C., Duckworth, D., Ramalingam, D., & Teo, I. (2020). Critical thinking: Skill development framework.
- Jannah, L. M., & Apriyanshah, C. (2021). Pengaruh Sosial Emosional terhadap Kemandirian Belajar Anak Usia 5-6 Tahun di Masa Pandemi Covid 19. *Jurnal Pendidikan Tambusai*, 5(3), 6246-6252.
- Kartikaningtyas, V., Kusmayadi, T. A., & Riyadi, R. (2018). The effect of brain based learning with contextual approach viewed from adversity quotient. In *Journal of Physics: Conference Series* (Vol. 1022, No. 1, p. 012014). IOP Publishing.
- Kristihana, O., & Ratu, N. (2018). Deskripsi Berpikir Kritis Dalam Memecahkan Masalah Bangun Datar Pada Siswa SMP Kelas VIII. *Genta Mulia: Jurnal Ilmiah Pendidikan*, 9(2), 150-161
- Kusmaharti, D. (2022). Self-regulated learning-based digital module development to improve students' critical thinking skills. *Al-Jabar: Jurnal Pendidikan Matematika*, 13(1), 211-220.
- Kusuma, D. A. (2020). Dampak penerapan pembelajaran daring terhadap kemandirian belajar (self-regulated learning) mahasiswa pada mata kuliah geometri selama pembelajaran jarak jauh di masa pandemi covid-19. *Teorema: Teori dan Riset Matematika*, 5(2), 169-175.
- Latipah, E., Kistoro, H. C. A., & Putranta, H. (2021). How Are the Parents Involvement, Peers and Agreeableness Personality of Lecturers Related to Self-Regulated Learning?. *European Journal of Educational Research*, 10(1), 413-425.
- Lestari, Y. N., Swistoro, E., & Purwanto, A. (2019). Pengaruh Pembelajaran Dengan Model Problem Solving Fisika Terhadap Hasil Belajar Kognitif Dan Kemampuan Berpikir Kritis Siswa. *Jurnal Kumparan Fisika*, 2(2), 121-128.
- Maysani, R., & Pujiastuti, H. (2020). Analisis kesulitan mahasiswa dalam mata kuliah statistika deskriptif. *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika*, 4(1), 32-49.
- Mulia, S., Ikhsan, M., & Duskri, M. (2021). Implementation of Situation-Based Learning Model To Improve The Junior High School Students' Critical Thinking And Self-Regulated Learning Skills. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 12(1), 14-25.

- Nur, I. R. D. (2016). Meningkatkan kemampuan berpikir kreatif matematis dan kemandirian belajar siswa dengan menggunakan model pembelajaran brain based learning. *JUDIKA (Jurnal Pendidikan Unsika)*, 4(1),26-41.
- Nurasiah, I., Rachmawati, N., Supena, A., & Yufiarti, Y. (2022). Literatur Riview: Model Pembelajaran Brain Based Learning di Sekolah Dasar. *Jurnal Basicedu*, 6(3), 3991-4003.
- Oates, S. (2019). The importance of autonomous, self-regulated learning in primary initial teacher training. In *Frontiers in Education* (Vol. 4, p. 102). Frontiers Media SA.
- Pelikan, E. R., Lüftenegger, M., Holzer, J., Korlat, S., Spiel, C., & Schober, B. (2021). Learning during COVID-19: the role of self-regulated learning, motivation, and procrastination for perceived competence. *Zeitschrift für Erziehungswissenschaft*, 24(2), 393-418.
- Prasetya, A. R., Hidayat, O. S., & Saladin, A. A. (2022). Pengembangan Modul PPKn Berbasis Brain Based Learning pada Pembelajaran PPKn Kelas IV Sekolah Dasar. *Efektor*, 9(2), 255-263.
- Prihatini, D., Hidayat, W., & Rohaeti, E. E. (2019). Hubungan antara kemampuan berpikir kritis matematis dan kemandirian belajar siswa SMA Cimahi. *Journal On Education*, 2(1), 167-172.
- Puspitasari, Y., Idayani, D., & Firdausia, N. (2021). Perbandingan Prestasi Belajar Matematika Siswa Berdasarkan Daya Nalar Matematis dan Berfikir Kritis di Kelas VIII MTs Sarji Ar-Rasyid. *Jurnal IKA PGSD (Ikatan Alumni PGSD) UNARS*, 9(1), 150-162.
- Putri, C. A., Munzir, S., & Abidin, Z. (2019). Kemampuan berpikir kreatif matematis siswa melalui model pembelajaran brain-based learning. *Jurnal Didaktik Matematika*, 6(1), 12-27.
- Rahman, M. H. (2020). Analisis Ranah Psikomotor Kompetensi Dasar Teknik Pengukuran Tanah Kurikulum Smk Teknik Konstruksi Dan Properti. *Jurnal Pendidikan Teknologi Dan Kejuruan*, 17(1), 53-63.
- Rosmauli, C., & Watini, S. (2022). Implementasi Model ATIK untuk Mengembangkan Kemampuan Kognitif Berpikir Logis dalam Kegiatan Menggambar di TK IT Insan Mulia Pancoran. *JIIP-Jurnal Ilmiah Ilmu Pendidikan*, 5(3), 888-894.
- Rulyansah, A., & Hasanah, U. (2018). Pengembangan Model Pembelajaran Tematik berdasarkan Brain based Learning. *Jurnal Tarbiyatuna: Kajian Pendidikan Islam*, 2(1), 40-57.
- Saputri, R., Nurlala, N., & Patras, Y. E. (2020). Pengaruh Berpikir Kritis Terhadap Hasil Belajar Matematika. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, 3(1), 38-41.
- Setiana, D. S., & Purwoko, R. Y. (2021). The Application of Mathematics Learning Model to Stimulate Mathematical Critical Thinking Skills of Senior High School Students. *European Journal of Educational Research*, 10(1), 509-523.
- Seventika, S. Y., Sukestiyarno, Y. L., & Mariani, S. (2018). Critical thinking analysis based on Facione (2015)–Angelo (1995) logical mathematics material of vocational high school (VHS). In *Journal of Physics: Conference Series* (Vol. 983, No. 1, p. 012067). IOP Publishing.
- Shabatat, K., & Al-Tarawneh, M. (2016). The Impact of a Teaching-Learning Program Based on a Brain-Based Learning on the Achievement of the Female Students of 9th Grade in Chemistry. *Higher Education Studies*, 6(2), 162-173.
- Tari, D. K., & Rosana, D. (2019). Contextual teaching and learning to develop critical thinking and practical skills. In *Journal of Physics: Conference Series* (Vol. 1233, No. 1, p. 012102). IOP Publishing.
- Wahyuni, S., & Pasaribu, L. H. (2022). Peningkatan Kemampuan Berpikir Kreatif dan Motivasi Siswa Melalui Pembelajaran Matematika Realistik. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(2), 1694-1707.
- Wong, J., Baars, M., Davis, D., Van Der Zee, T., Houben, G. J., & Paas, F. (2019). Supporting self-regulated learning in online learning environments and MOOCs: A systematic review. *International Journal of Human-Computer Interaction*, 35(4-5), 356-373.
- Zahroh, H., Hafidah, H., Dhofir, D., & Zayyadi, M. (2020). Gerakan Literasi Matematika dalam Peningkatan Kemampuan Pemecahan Masalah Matematis Siswa. *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, 9(2), 165-177.
- Zakaria, L. M. A., Purwoko, A. A., & Hadisaputra, S. (2021). Brain-Based Learning Teaching Materials to Improve Critical Thinking Skills and Literacy Skills of Students. In *5th Asian Education Symposium 2020 (AES 2020)* (pp. 178-181). Atlantis Press.