JURNAL BIOTERDIDIK: WAHANA EKSPRESI ILMIAH
(*Journal of Bioterdidik: Scientific Expression Media*)
Vol. 11 No. 3, December 2023, page. 348-357
http://jurnal.fkip.unila.ac.id/index.php/JBT/
doi: 10.23960/jbt.v11.i3.28490
e-ISSN: 2621-5594
p-ISSN: 2302-1276

The Effect of the Scientific Inquiry Learning Model on the Topic of the Respiratory System on the Critical Thinking Skills of Grade XI Senior High School Students

Pooja Hujaibah[1*], Nirwana Anas[1], Ummi Nur Afinni Dwi Jayanti[1]
[1]Program Studi Pendidikan Biologi, Universitas Islam Negeri Sumatera Utara Medan, Jl. William Iskandar Ps. V, Medan Estate, Kec. Percut Sei Tuan, Kab. Deli Serdang, Sumatera Utara, Indonesia
[*]*Corresponding author*: poojahujaibah@uinsu.ac.id

Received: August 28, 2023 *Accepted: September 30, 2023* *Online Published:December 30, 2023*

Abstract: This study aims to determine the effect of the application of the Scientific Inquiry learning model on students' critical thinking skills on the subject matter of the respiration system in XI grade. This research methodology uses quantitative methods with the type of quasi experiment. The study population amounted to 150 students from XI grade Senior High School 1 Sei Suka. The sample of this study consisted of 2 classes determined by cluster random sampling technique, namely X grade as an experimental class using the Scientific Inquiry learning model and X grade as a control class using conventional learning. The instruments used in this study are critical thinking ability test instruments totaling 11 essay test questions that have been validated by one validator and have been tested for item validity. The results showed that the average critical thinking skills of students in the experimental class taught using the Scientific Inquiry learning model were in the high category and the average critical thinking skills of students in the control class taught using the conventional learning model were in the low category, this is based on the average postest value of the experimental class which is 77.3443 and the control class which is 37.4957. The results of hypothesis testing using Independent Sample t-test statistics show that there is an effect of the Scientific Inquiry learning model on students' critical thinking skills on the material of the respiration system in XI grade.

Keywords: critical thinking skills of students, scientific inquiry learning model, conventional learning

INTRODUCTION

Critical thinking—alongside creativity, collaboration, and communication—is a core 21st-century skill and is strongly emphasized in the

2013 national curriculum (Zubaida, 2018). Ennis (2011) defines critical thinking as rational and reasoned thinking, where good thinking involves logical reasoning and thoughtful consideration before making decisions. Based on this perspective, critical thinking is not impulsive but a structured process that helps individuals identify situations or arguments before drawing conclusions (Ennis, 1996).

Rohani (2013) emphasized that science should be taught through active learning processes, where argumentation and concept development occur through thinking. Costa (1985) also highlighted the need for conceptual understanding through structured thinking models. Chiappetta (2010) pointed out that science fundamentally involves theory, research, and knowledge. Pomahac et al. (2007) argued that thinking skills and understanding the scientific method are essential components of science education. Similarly, Indonesia's Ministry of National Education mandates that critical thinking must be an essential part of every student's learning experience, preparing them for the future (Udin & Cheng, 2015).

Ben-Chaim et al. (2000), supported by OECD data in 2019, stated that critical thinking is vital for life success, helping individuals manage change and integration. However, Indonesia ranked among the lowest in the 2018 PISA results. Indonesian students scored mostly at levels 1 and 2 out of 6 in the assessment. Agnafia (2019) reported Indonesian students' critical thinking indicators as follows: explanation (72%), interpretation (63%), analysis (31%), regulation (51%), evaluation (46%), and inference (62%). Classroom observations at SMA Negeri 1 Sei Suka (Grade XII Science Program) further confirm this. The results showed low levels of critical thinking: elementary clarification (53%), basic support (33%), inference (26%), clarification (20%), and strategy and tactics (16%).

The topic of human respiration in biology is conceptually complex. Students are required to apply high-level thinking to understand how organs interact within a system (Henno et al., 2008). According to Cimer (2012), biology is challenging due to abstract concepts, the use of Latin terms, and phenomena not directly observable. Additionally, biology instruction often relies on memorization (Suryanti et al., 2019), making it difficult for students to truly understand biological content (Solikhatum et al., 2015). Thus, critical thinking becomes essential in understanding and solving biological problems (Murti, 2009; Surip, 2017).

To address these challenges, a learning model is needed that stimulates students' intellectual development. Scientific inquiry is one such model. Puspitasari & Rodiyana (2019) found this model to be effective in enhancing students' higher-order thinking. Yonanda et al. (2019) further affirmed that scientific inquiry is efficient and promotes critical thinking development. Sani (2013) categorized scientific inquiry as part of the data-processing model family, where learning is based on observation and data analysis (Trianto, 2009; Joyce et al., 2009).

Research at the university level by Fuad et al. (2017) also found that inquiry-based learning positively influences students' self-efficacy and cognitive development, regardless of the media used. Similarly, Eunice (2017) concluded that scientific inquiry supports high-order thinking in chemistry learning. Despite numerous studies on scientific inquiry, limited research explores its impact on critical thinking specifically in the context of the human respiratory system in high school biology. Given that organ systems are considered complex biological content (Henno et al., 2008) and are often abstract or difficult to visualize (Cimer, 2012), the respiratory system is an ideal topic for testing the effectiveness of scientific inquiry on critical thinking. Thus, this study aims to examine the impact of the Scientific Inquiry learning model on students' critical thinking skills when learning about the respiratory system.

METHOD

This study was conducted at SMA Negeri 1 Sei Suka, Sei Suka Subdistrict, Batu Bara Regency during the 2023/2024 academic year. The research took place between March 2023 and April 2024. The population includes all Grade XI science students at SMA Negeri 1 Sei Suka for the academic year 2023/2024. The school consists of several Grade XI Science classes: XI MIPA-1, XI MIPA-2, XI MIPA-4, XI MIPA-5, and XI MIPA-6 in total 150 students.

Before selecting the sample, the researcher conducted an equivalence test across the six Grade XI science classes. This test was based on the students' exam scores and analyzed using ANOVA to determine whether the classes were statistically equivalent. From these results, two classes were selected: one as the control group (taught using traditional instructional methods) and the other as the experimental group (taught using the scientific inquiry model). The sampling process used random sampling techniques, specifically cluster random sampling, as described by Ngatno (2015), where entire class groups are treated as clusters for sampling purposes.

Tabel 1. Scoring Guidelines for Critical Thinking Skills.

Assessed Indicator	Descriptors	Maximum Score
Elementary Clarification	1. Focusing on the question	4
	2. Analyzing arguments	4
	3. Responding to clarification questions about an explanation	4
Basic Support	4. Considering the credibility of a source	4
	5. Observing and considering observation results	4
Inference	6. Making inductions and evaluating induction results	4
	7. Making decisions and considering the consequences	4
Advanced Clarification	8. Defining terms and evaluating definitions	4
	9. Identifying assumptions	4
Strategy and Tactics	10. Formulating and deciding on an action	4

Assessed Indicator	Descriptors	Maximum Score
	11. Communicating arguments in written form	4

This study aims to determine whether a particular instructional model (in this case, scientific inquiry) influences student outcomes—specifically, critical thinking skills. The scoring guidelines are provided in Table 1. The scores obtained by students on each item were summed to produce a total raw score. The applicability of the research instrument was assessed by administering it to a group other than the control and experimental groups. After the instrument was tested, the validity and reliability of each item were examined to determine whether they could be used as a part of the research tool. Items that did not meet the required standards were excluded and not used in the final instrument. According to Sudjana (2002), to calculate the standard deviation, the square root of the variance is taken. The normality test used in this study was the Liliefors test, then conducted Anova test.

RESULTS AND DISCUSSION

The aim of this study was to examine the effect of the scientific inquiry learning model on the critical thinking skills of Grade XI senior high school students in the context of human respiration. The study employed an academic research design, with class selection determined through random group sampling. From a total population of five classes, two were selected: Class XI MIPA 1 and Class XI MIPA 2 at SMA Negeri 1 Sei Suka.

At the end of the study, two different instructional approaches were applied to the sample groups. The experimental class received instruction using the scientific inquiry learning model, while the control class was taught using traditional learning methods. The post-test results of both groups are presented in Table 2. Based on the data presented in Figure 1, it can be concluded that the Scientific Inquiry learning model has a significant positive impact on students' critical thinking skills compared to the conventional learning model. After collecting the pre-test and post-test data from both the experimental and control classes, preliminary statistical tests were conducted, including tests for data normality and homogeneity.

Table 2. Frequency Distribution of Post-Test Scores.

Experiment				**Control**			
Interval	**Frk**	**Mean**	**SD**	**Interval**	**Frk**	**Mean**	**SD**
54,54-60,54	2			47,72-53,72	10		
61,54-67,54	2			54,72-60,72	8		
68,54-74,54	4	77,3443	9,36985	61,72-67,72	7	59,5410	11,07531
75,54-81,54	12			68,72-74,72	2		
82,54-88,54	6			75,72-81,72	1		
89,54-95,54	4			82,72-88,72	2		
N = 30				N = 30			

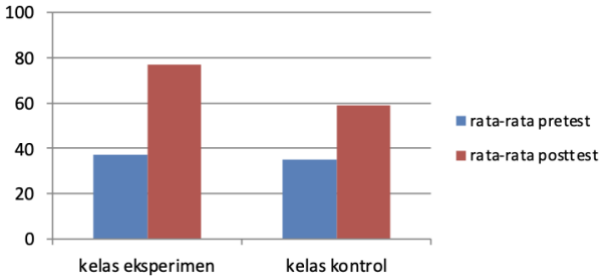

Figure 1. Comparison of Students' Average Critical Thinking Scores in the Experimental and Control Groups

Table 3. Normality Test of Research Data.

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Eksperimen	,090	30	,200*	,979	30	,804
Posttest Eksperimen	,135	30	,175	,963	30	,365
Pretest Kontrol	,117	30	,20*	,973	30	,623
Posttest Kontrol	,143	30	,121	,859	30	,001

The decision rule for interpreting the Liliefors normality test is as follows: If the significance value (Sig.) is less than 0.05, the data are not normally distributed. If the significance value (Sig.) is greater than 0.05, the data are normally distributed. The results of the Liliefors normality test show the following: The pre-test scores in the experimental group have a significance value of 0.200 > 0.05, indicating that the data are normally distributed. The post-test scores in the experimental group have a significance value of 0.135 > 0.05, also indicating normal distribution. The pre-test scores in the control group have a significance value of 0.200 > 0.05, suggesting normal distribution. The post-test scores in the control group have a significance value of 0.121 > 0.05, confirming that the data are also normally distributed. Since all datasets are normally distributed, hypothesis testing can be conducted using parametric methods, specifically the Independent Samples t-Test.

The Sig. value for Based on Mean in the homogeneity test of the students' critical thinking post-test scores is 0.338 > 0.05, indicating that the data variances are homogeneous. Therefore, one of the assumptions (although not strictly required) for conducting the Independent Samples t-Test has been met. According to the output in Table 4.4, the number of students assessed for critical thinking skills was 30 in the experimental class and 30 in the control class. The mean post-test score of the experimental group was 77.3443, while the control group had a mean of 59.5410. Thus, based on descriptive statistics, there appears to be a difference in average critical thinking skills between the two groups.

To determine whether this difference is statistically significant, we refer to the results of the Independent Samples t-Test. The result showed section Equal variances assumed, the Sig. (2-tailed) value is 0.000 < 0.05. According to the decision rule of the Independent Samples t-Test, this means the null hypothesis

(H_0) is rejected and the alternative hypothesis (H_a) is accepted. Therefore, it can be concluded that there is a statistically significant difference in the average critical thinking skills between students in the experimental and control groups.

Discussion

The results of this study indicate that the Scientific Inquiry learning model led to higher critical thinking skills in the experimental group compared to the control group, which was taught using a conventional learning model. The critical thinking skills test instrument prepared by the researcher consisted of 11 questions, with each item representing one of the indicators of critical thinking skills as proposed by Ennis (1996), namely: Elementary clarification – providing simple explanations, Basic support – developing foundational reasoning, Inference – drawing conclusions, Advanced clarification – giving further explanations, Strategy and tactics – planning and implementing actions.

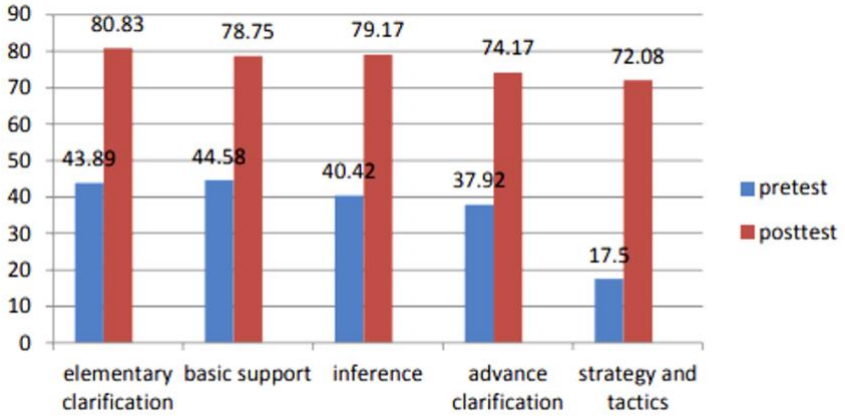

Figure 2. Improvement each indicator of critical thinking of experiement class.

Based on the five indicators of critical thinking skills in the experimental class, it can be concluded that the average post-test scores for all indicators fall within the high category. Among these indicators, "strategy and tactics" showed the highest percentage increase in critical thinking skills, at 57.58%, while "basic support" had the lowest percentage increase, at 34.17%.

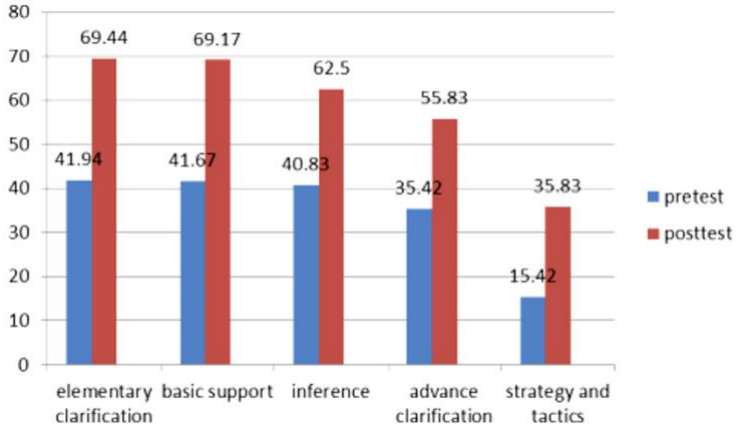

Figure 3. Improvement of each indicator of critical thinking of control class.

From the five indicators of critical thinking skills assessed in the control group, none of the average post-test scores reached the high category. The highest post-test score was only within the moderate category. Nevertheless, there was a notable percentage increase across all indicators. Among them, the "elementary clarification" and "basic support" indicators had the highest improvement, with a 27.5% increase, while "advanced clarification" and "strategy and tactics" had the lowest increase, at 20.41%.

The research data were grouped into two phases: data before and after treatment. Two different learning models were applied to the control and experimental classes. The teacher distributed the student worksheets to each group and guided students to complete tasks based on the worksheets. During the experiment, students were instructed to collect data, analyze the results, and draw conclusions. After the experiment, the teacher provided follow-up exercises and outlined the lesson plan for the next session.

In the third meeting, the teacher introduced the topic of the dangers of smoking, showing visual aids (e.g., images of smoking-damaged organs plugged into electrical sockets) to stimulate discussion. The teacher encouraged students to formulate questions and draw conclusions based on visuals and facts. Students were also asked to read aloud their written reflections before class discussions.

During this session, students were assessed through exercises to measure their understanding of respiration. The session ended with an introduction to the upcoming practical topic: the harmful effects of cigarette smoke on the lungs. In the fourth meeting, the teacher reconvened the groups, briefly reviewed the previous session, distributed s again, and directed the students through another inquiry-based experiment. Students were guided in collecting and analyzing data and drawing conclusions. They were also asked to explain their results and complete written exercises. In contrast, the traditional learning method used in the control class (XI MIPA 2) focused primarily on teacher-centered activities, such as observing, questioning, and explaining concepts, with limited time for student reflection. This model lacked active student involvement and direct inquiry, which are essential for developing higher-order thinking skills.

The expected student outcomes after treatment show a notable difference: Experimental Class: Post-test average = 77.3443, Control Class: Post-test average = 59.5410. This difference suggests that the scientific inquiry model encourages greater active student engagement, enhancing critical thinking more effectively than conventional methods. According to Gulo (in Trianto, 2010), inquiry-based learning fosters student skills in exploration, measurement, and evaluation, enabling students to become discoverers in their own learning process. This aligns with the idea that inquiry stimulates scientific reasoning and reflective thought.

Joyce, Weil, and Calhoun (2009) emphasized that emotional and intellectual development is better supported through inquiry methods than by traditional rote instruction. Inquiry-based activities engage students in meaningful experiences that require them to apply and process information actively, rather than passively receiving content.

Several obstacles were observed during the implementation of the scientific inquiry model. As this approach was new for many students, some were confused, especially in the initial stages. This disrupted classroom focus and made it difficult for some to follow the process effectively. According to Fanani (2016), around 10% of teachers struggle to motivate students to observe and question phenomena actively. There were varying levels of engagement—some students were highly active in questioning and responding, while others remained passive. Fanani (2016) also found that 95%–97% of teachers experience challenges in encouraging all students to participate in inquiry-based lessons. Some students dominated group work, while others remained disengaged. During worksheet discussions, it was often the more capable students who completed tasks on behalf of the group. Malinda (2018) reported that only 40% of students were willing to respond to worksheet questions independently.

CONCLUSION

Based on the research objectives and data analysis, the following conclusions can be drawn: The Scientific Inquiry learning model effectively enhanced students' critical thinking skills in the experimental class (XI MIPA 1) at SMA Negeri 1 Sei Suka. In the 2022/2023 academic year (second semester), the average pre-test score was 37.4957, which increased to 77.3443 after treatment. In contrast, the control class (XI MIPA 2), taught using traditional learning methods on the same topic (Human Respiratory System), showed a pre-test average of 35.6770 and a post-test average of 59.5410. These findings indicate that the Scientific Inquiry model promotes more significant improvement in students' critical thinking skills compared to conventional approaches.

REFERENCES

Agnafia, D. N. (2019). Analisis Kemampuan Berpikir Kritis Siswa Dalam Pembelajaran Biologi. *Carbohydrate Polymers*, *6*(1), 5–10.

Astuti, D. W. (2020). Penerapan Model Inkuiri Sosial terhadap Keterampilan Berpikir Kritis Mata Pelajaran IPS di Sekolah Dasar. *Jurnal Ilmu Pendidikan (JIP) STKIP Kusuma Negara*, *12*(1), 35–42.

Ben-Chaim, D., Ron, S., & Zoller, U. (2000). The disposition of eleventh-grade science students towardcritical thinking. *Journal of Science Education.* 22(6), 571-582

Chiappetta, E.L. dan T.R. Koballa. 2010. Science Instruction in The Middle and Secondary Schools: Developing Fundamental Knowledge and Skills. United State of America: Pearson Education Inc.

Cimer, A. (2012). What makes biology learning difficult and effective: students' views. *Educ Res Rev*, *7*, 61-71.

Costa, A. L. (Eds). (1985). *Developing Minds; A Resource Book for Teaching Thinking.* ASDC Publications.

Ennis. R.H. (2011). *The Nature of Critical Thinking : An Outline of Critical Thinking Dispositions and Abilities.*

Ennis.R.H. (1996). *Critical Thinking*. Prentice Hall,Inc.

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving junior high schools' critical thinking skills based on test three different models of learning. *International Journal of Instruction*, *10*(1), 101–116.

Ginting, S., Sinulingga, K., Tampubolon, T., & Rajagukguk, J. (2021). Analysis of Students Critical Thinking Ability using Models Scientific Inquiry. *Journal of Physics: Conference Series*.

Greenwald, R. R., & Quitadamo, I. J. (2014). A mind of their own: Using inquiry-based teaching to build critical thinking skills and intellectual engagement in an undergraduate neuroanatomy course. *Journal of Undergraduate Neuroscience Education*, *12*(2), 100–106.

Gunawan, I. (2013). *Metode Penelitian Kualitatif. Teori dan Praktik*. PT Bumi Aksara.

Karagos, M. & Cakir, M. (2011). Problem solving in genetics: conceptual and procedural difficulties. *Educational Sciences: Theory & Practice*, *11*, 1668–1674.

Khaleel Younis, B. (2017). The Effects of Scientific Inquiry Simulations on Students' Higher Order Thinking Skills of Chemical Reaction and Attitude towards Chemistry. *American Journal of Educational Research*, *5*(11), 1158–1161.

Latifa, B. R. A., Verawati, N. N. S. P., & Harjono, A. (2017). Pengaruh Model Learning Cycle 5E (Engage, Explore, Explain, Elaboration, & Evaluate) Terhadap Kemampuan Berpikir Kritis Peserta Didik Kelas X MAN 1 Mataram. *Jurnal Pendidikan Fisika Dan Teknologi*, *3*(1), 61–67.

Maryam, M., Kusmiyati, K., Merta, I. W., & Artayasa, I. P. (2020). Pengaruh Model Pembelajaran Inkuiri Terhadap Keterampilan Berpikir Kritis Siswa. *Jurnal Pijar Mipa*, *15*(3), 206–213.

Muswita, Budiarti, R.S, Sulistiani, E. 2016. Analisis Kemampuan Berpikir Kritis Siswa Lintas Minat Pada Pembelajaran Biologi Kelas X IIS SMA Negeri 11 Kota Jambi. Jurnal BIODIK. Vol 2 (1). Hal 13- 19

Ningsih, S. M., Bambang, S., & Sopyan, A. (2012). Implementasi Model Pembelajaran Process Oriented Quided Inquiry Learning (POGIL) untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *Unnes Physics Educations Journal.*, *2*, 22–52.

OECD. (2019). South Africa: Education At a Glance 2019. In *Education at a Glance: OECD Indicators*.

Pritananda, dkk. 2015. Kemampuan Berpikir Kritis Siswa pada Aspek Inference dalam Menyelesaikan Soal Cerita Teorema Pythagoras. Matematika FKIP Untan Pontianak. Hal. 1- 8

Ratna Hidayah Moh. Salimi, T. S. S. (2017). Critical Thinking Skill: Konsep Dan

Inidikator Penilaian. *Taman Cendekia*, *3*(8), 85–102.

Rosmaiyadi. (2020). Analisis Kemampuan Berpikir Kritis Matematis Siswa Dalam Learning Cycle 7e Berdasarkan Gaya Belajar. *Jurnal Pendidikan Matematika FKIP Univ. Muhammadiyah Metro*, *5*(3), 248–253.

Siti Zubaidah. (2016). Keterampilan Abad Ke-21: Keterampilan Yang Diajarkan Melalui Pembelajaran. seminar nasional pendidikan. Universitas Negeri Malang

Solikhatun, I., Santosa, S., dan M. (2015). Pengaruh penerapan reality based learning terhadap hasil belajar biologi siswa kelas X SMA Negeri 5 Surakarta tahun pelajaran 2012/2013. *Jurnal Pendidikan Biologi*, *7*, 49–60.

Sopian, A. (2016). Tugas, Peran, Dan Fungsi Guru Dalam Pendidikan. *Raudhah Proud To Be Professionals : Jurnal Tarbiyah Islamiyah*, *1*(1), 88–97.

Sugiyono. (2015). *Metode Penelitian Kombinasi (Mix Methods)*. alfabeta.

Sukendra, I. K. I. K. S. A. (2020). Instrumen Penelitian. In *Journal Academia*.

Surip, M. (2017). *Berpikir Kritis Analisis Kajian Filsafat Ilmu*. Halaman Moeka.

Syutaridho. (2016). Mengontrol Aktivitas Berpikir Kritis Siswa dengan Memunculkan Soal Berpikir Kritis. *Jurnal Pendidikan Matematika JPM RAFA*, *2*, 31–40.

Trianto. (2009). *mendesain model pembelajaran inovatif progresif*. kencana.

Tursina Clarita1, R. A. S. (2019). *Model pembelajaran scientific inquiry dalam meningkatkan kemampuan berpikir kritis siswa di Sma N 1 Percut Sei Tuan*. *5*(3), 47–52.

Veronika Horohiung, Sarkadi dan Murni Winarsing (2017). *pengaruh strategi pembelajaran dan kemampuan berpikir ktitis terhadap hasil nelajar sejarah siswa SMA Negri 72 Jakarta*. 6(1), 1-10.

Zaini, M. (2016). Guided Inquiry Based Learning on the Concept of Ecosystem Toward Learning Outcomes and Critical Thinking Skills of High School Students. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *6*(6), 53.