

Analysis of Critical Thinking Ability on Senior High School Students in Biology Classroom Based on Modified FRISCO Indicators

Rifka Almunawarah¹, Adnan², Arsad Bahri³

¹Universitas Negeri Makassar, Indonesia
Email: rifkaalmunawarah1[at]email.com

²Universitas Negeri Makassar, Indonesia
Email: adnan[at]unm.ac.id

³Universitas Negeri Makassar, Indonesia
Email: arsad.bahri[at]unm.ac.id

Abstract: *This study aims to analyze the critical thinking ability of class XI senior high school biology students in Makassar City, Indonesia, based on modified FRISCO indicators. The survey was conducted from June to September 2023 in Makassar City. This study involved 685 class XI biology students from 8 Senior High Schools (SMA). The instrument used was a critical thinking instrument in the form of essay questions. Before being used, the critical thinking instrument was validated by three expert validators. Data collection was done by giving a critical thinking test for 90 minutes. Test results were examined using the modified FRISCO critical thinking rubric. The results showed that the critical thinking ability of biology high school class XI students in Makassar City was 62.26 ± 11.43 with good criteria. Of the 685 students involved, 378 (55.18%) were able to think critically with good and very good categories, but as many as 307 (44.81%) students with critical thinking skills in the category of less good and not good. Of the six critical., thinking indicators, focus, reason, situation, and clarity are in a good category and two other indicators, namely conclusion and overview, are still classified as poor.*

Keywords: Critical thinking; FRISCO indicators; Merdeka curriculum.

1. Introduction

The demands of the 21st century in the scope of education emphasize the ability of individuals to be competitive in a rapidly changing global environment. The ability that the individual must possess is high-level thinking competence. These competencies include critical thinking, creativity and innovation, communication skills, collaboration, and confidence. The five things conveyed by the government that become the target character of students are attached to the evaluation system and are 21st-century skills. Higher Order Thinking Skills (HOTS) are applied to compile because of the low ranking of the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) compared to other countries so the standard of national exam questions is tried to be improved to catch up [1]. Therefore, individuals must be highly competitive on a global scale. All of that can be fulfilled by the way each individual is trained to optimize thinking skills.

The ability to think is to process information mentally or cognitively. More formally, thinking is the rearrangement or cognitive manipulation of both information from the environment and symbols stored in long-term memory. Thus, thinking is a symbolic representation of some event or item [2]. Thinking is generally defined as a mental process that can produce knowledge through the combination of perception and elements in the mind [3]. According to the Cambridge International Examination (CIE) Curriculum, thinking skills consist of two main components, namely problem-solving and critical thinking [4]. One of the

thinking skills that is very important and needed by everyone is critical thinking skills [5]. The thinking process is gradual from low-order thinking to high-order thinking. Basic thinking processes are finding relationships, connecting cause and effect, transforming, classifying, and qualifying. Complex, higher-order thinking processes can be categorized into four groups: problem-solving, decision-making, creative thinking, and critical thinking.

Critical thinking is an educational demand that includes rational hypothesis-making through activities to examine phenomena, questions, situations, and problems [6]. Critical thinking can also mean a series of skill aspects that students can optimize through simultaneous revision and application of skills. It can have an impact on internalizing the ability to think [7]. Critical thinking is a person's ability and tendency to make and assess evidence-based conclusions [8]. Critical thinking is a reasonable thought that includes indicators abbreviated to FRISCO, namely focus, reason, inference, situation, clarity, and overview, while creative thinking skills according to Munandar include fluency, flexibility, originality, and elaboration [9]. Critical thinking can be the main capital as a basis for students not to be able to think creatively. A person can think creatively, without having the ability to think critically first [10],[11]. Critical thinking skills have various benefits.

The benefits of critical thinking skills in the classroom include students often asking questions, there is interest in learning activities, increasing student activity, and making students determine the conclusions of learning outcomes.

Volume 12 Issue 10, October 2023

www.ijsr.net

Licensed Under Creative Commons Attribution CC BY

Students can also reinforce each other and have an impact by stimulating the development and ability of students' critical thinking skills [12]. Critical thinking skills help and perseverance of Generation Z in improving learning outcomes [13], [14]. The process of improving thinking essentially creates a habit of reflection and questioning every aspect of life. Educators want students to use higher cognitive orders such as critical thinking but tend in practice to focus on students' efforts to memorize or the tasks given are at a lower cognitive level [15]. Critical thinking skills can be implemented in a Merdeka curriculum.

The implementation of the independent curriculum according to Permendikbud No. 262/M/2022 concerning Process Standards uses 3 (three) learning models that are expected to shape scientific, and social behavior and develop curiosity and critical thinking skills. The three models are (1) the Discovery/Inquiry Learning model [16], [17], [18], (2) the Problem-based Learning (PBL) model [19], [20], [21], [22], (3) Project-based Learning (PJBL) model [23], [24], [25], [26]. In addition to the 3 models listed in Permendikbud Number 22 of 2016, teachers are also allowed to develop learning in the classroom by using other learning models, such as Cooperative Learning [27],[28] which has various methods such as Jigsaw, Numbered Head Together (NHT), Make a Match, Think-Pair-Share (TPS), Example not Example, Picture and Picture, and others [1]. In addition, improving critical, thinking can be done through Case-Based Learning [29], [30], [31]. Game-Based Learning [32], [33], [34], Discussion-Based Learning (Socratic Questioning) [35], [36], [37], and Technology-Based Learning [38], [39], [40], [41]. To design learning that thinks critically, the problem that can arise is conditioning the classroom as a learning environment for critical thinking [1]. Therefore, critical thinking can be optimized in students.

Students deepen their knowledge and develop various skills that will shape their future. One of the skills that is very important to equip students with is critical thinking. Students who have this ability will be able to analyze problems, conclude various aspects and points of view, and determine solutions to solve these problems [42]. Students begin to learn subjects that are more complex and require deep understanding. Critical thinking helps students parse complex information, assess the accuracy of data, and identify strong arguments. The presence of critical thinking skills in students can develop effective communication skills and overcome difficult challenges in the future [43]. They will be able to identify the root of the problem, find effective solutions, and evaluate the results of the choices they make. Critical thinking helps them to conduct risk-benefit analyses and consider the consequences of each choice they make [44]. High school students who are skilled in critical thinking will be able to construct logical arguments and support their opinions with strong evidence. Therefore, developing students' critical thinking skills in learning is one of the efforts to improve student learning outcomes [45]. These skills are important in communicating effectively, not only in academic settings but also in everyday life.

This study aims to determine the critical thinking skills of high school biology students in Class XI in Makassar City. Critical thinking assessment indicators are carried out by

referring to critical thinking indicators according to Ennis [9] which are abbreviated as FRISCO with six aspects, namely Focus, Reason, Inference, Situation, Clarity, and Overview. Focus is to identify the problem properly, reason is the reasons given are logical or not to be concluded as specified in the problem, inference is if the reason developed is appropriate, then the reason must be sufficient to reach the actual conclusion, situation is comparing with the actual situation, clarity is there must be clarity of terms and explanations used in the argument so that there is no error in concluding and overview is checking something that has been found, decided, noticed, studied, and concluded [46], [9].

2. Method

This research is a quantitative data collection study with a type of survey research, by examining an event without any prior treatment of the object to be studied. The data source of this research is primary data, primary data obtained from respondents through direct test processing without intermediaries. This research was conducted on students of class XI SMAN Makassar City. The subjects of this study were 685 students who had received cell material. The sampling technique uses purposive random sampling, with the representation of each SMAN based on the category of schools that implement the Merdeka Curriculum. Data were collected by a test in the form of critical thinking questions consisting of six questions that had been validated by a material expert with a test implementation time of 90 minutes. Questions are the indicators of critical thinking skills according to Ennis [9] which are abbreviated as FRISCO, namely focus, reason, inference, situation, clarity, and overview.

This research was conducted on students of class XI SMAN Makassar City. The subjects of this study were 685 students who had received cell material. The sampling technique uses purposive random sampling, with the representation of each SMAN based on the category of schools that implement the Merdeka Curriculum. Data were collected by a test in the form of critical thinking questions consisting of six questions that had been validated by a material expert with a test implementation time of 45 minutes. Questions are the indicators of critical thinking skills according to Ennis [9] which are abbreviated as FRISCO, namely Focus, Reason, Inference, Situation, Clarity, and Overview. The procedure begins with determining the school intended for research, preparing critical thinking question instruments, and preparing critical thinking rubrics, then the questions and critical thinking rubrics are validated by expert validators. The data in each school has been determined, and then the data is analyzed using Excel. Calculations were made on percentage, average, and standard deviation.

3. Results

The results of research on the critical thinking skills of high school biology students in class XI in Makassar City are shown in Table 1. Table 1 shows that out of 685 students, there are 9 (1.31%) students with poor critical thinking skills, 298 (43.50%) students with fairly good critical thinking skills, 369 (53.87%) students with good critical

thinking skills, and 9 (1.31%) students with excellent critical thinking skills. The average critical thinking ability of high school biology students in class XI in Makassar City is 62.26 ± 11.43 . Critical thinking criteria are considered good if the value obtained is between 60.00-89.99. Based on these criteria, the critical thinking ability of biology students in class XI high school in Makassar City is classified as good.

Table 1: Critical Thinking Ability of High School Biology Students in Grade XI in Makassar City

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	9	1,31
2	60,00 – 89,99	Good	369	53,87
3	30,00 – 59,99	Less Good	298	43,50
4	0,00 – 29,99	Not Good	9	1,31
Total			685	100,00

Table 2: Critical Thinking Skills of High School Biology Students in Grade XI in Makassar City Based on Their School of Origin

School	Kategori								Total
	Not Good		Less Good		Good		Very Good		
	Total	%	Total	%	Total	%	Total	%	
SMAN 1	4	7,14	4	7,14	46	82,14	2	3,57	56
SMAN 2	1	1,27	29	36,71	49	62,03	0	0,00	79
SMAN 3	0	0,00	54	44,26	67	59,82	1	1,79	122
SMAN 4	1	1,61	26	41,94	34	54,84	1	1,61	62
SMAN 5	1	0,99	49	48,51	50	49,50	1	0,99	101
SMAN 8	1	0,82	61	50,00	58	47,54	2	1,64	122
SMAN 9	1	1,27	43	54,43	34	43,04	1	1,27	79
SMAN 11	0	0,00	32	50,00	31	48,44	1	1,56	64

The critical thinking ability of high school biology students in class XI in Makassar City based on modified FRISCO indicators is shown in Table 3. Table 3 shows that the critical thinking ability of high school biology students in class XI in Makassar City based on FRISCO indicators averaged 62.26 ± 11.43 with a good category, of the 6 critical thinking indicators, Focus, Reason, Situation, and Clarity have an average greater than 6.00. The assessment criteria the average value of critical thinking skills between 6.00-8.99 is declared good. Based on these criteria, the four indicators are considered good. In the other 2 indicators, namely inference, and overview, the average ability of students is still < 6.00 or is between 30.00-59.99 with poor criteria. Based on these criteria, biology students in grade XI in Makassar City are still considered poor in terms of making conclusions and overviews.

Table 3: Critical Thinking Ability of Class XI High School Biology Students in Makassar City Based on Modified FRISCO Indicators

No	Indicator	\bar{x} Rata \pm SD	Category
1	Focus	6,55 \pm 1,13	Good
2	Reason	6,34 \pm 1,09	Good
3	Interference	5,90 \pm 1,26	Less Good
4	Situation	6,29 \pm 1,14	Good
5	Clarity	6,17 \pm 1,14	Good
6	Overview	5,68 \pm 1,35	Less Good

The ability of students to answer questions on the focus indicator can be seen in Table 4, the critical thinking ability of students with focus indicators is in a good category. Of the 685 learners, 499 (72.85%) learners have been able to

Table 1 shows that there are still 307 (44.81%) students with critical thinking skills in the poor and not good categories. These results indicate that high school students in Makassar City still need intensive handling so that their critical thinking skills can be improved. On the other hand, the number of students who were able to think critically very well was only 9 (1.31%). This number is still classified as very low. Although the average critical thinking ability of high school biology students in grade XI in Makassar City is classified as good, there are still 4 schools with a percentage of students who can think critically well below 50%, namely SMAN 5, SMAN 8, SMAN 9, and SMAN 11.

identify problems well, and 14 (2.04%) are in the excellent category. Table 4 also shows that there are still 149 (21.75%) learners in the poor category and 4 (0.58%) in the poor category.

Table 4: Critical Thinking Ability of Class XI High School Biology Students in Makassar City Based on Focus Indicator

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	14	2,04
2	60,00 – 89,99	Good	499	72,85
3	30,00 – 59,99	Less Good	149	21,75
4	0,00 – 29,99	Not Good	4	0,58
Total			685	100,00

The ability of students to answer questions on the reason indicator can be seen in Table 5, the critical thinking ability of students in this category is a good category because 485 (70.80%) students have been able to provide reasons that are logical or not to be concluded as specified in the problem, and 13 (1.90%) in the very good category. Table 5 also shows that there are still 162 (23.65%) learners in the less good category and 6 (0.88%) in the not good category.

Table 5: Critical Thinking Ability of Class XI High School Biology Students in Makassar City Based on Reason Indicator

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	13	1,90
2	60,00 – 89,99	Good	485	70,80
3	30,00 – 59,99	Less Good	162	23,65
4	0,00 – 29,99	Not Good	6	0,88
Total			685	100,00

The ability of students to answer questions on the conclusion indicator inference, it can be seen in Table 6 that the critical thinking ability of students in this category is in the poor category because the ability of students to provide answers to logical reasons is considered to be lacking, it can be proven in the research results that the percentage obtained is below 50%, namely only 341 (49.78%) students who show a good category, and 2 (0.2%) with an outstanding category. Table 6 also shows that there are 284 (41.46%) in the poor category and 15 (2.19%) in the poor category.

Table 6: Critical Thinking Ability of High School Biology Students in Grade XI in Makassar City Based on Inference Indicators.

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	2	0,29
2	60,00 – 89,99	Good	341	49,78
3	30,00 – 59,99	Less Good	284	41,46
4	0,00 – 29,99	Not Good	15	2,19
Total			685	100,00

Table 7 shows the ability of students to answer questions on the situation indicator where the ability of students to answer on this indicator is in the good category seen from the percentage obtained above 50% with the achievement of students who can answer questions based on situation indicators reaching 471 (68.76%) and 7 (1.02%) in the very good category. In addition, it is also shown that there are 183 (26.72%) who are in the less good category and there are 6 (0.88%) in the not good category.

Table 7: Critical Thinking Ability of High School Biology Students in Grade XI in Makassar City Based on Situation Indicator

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	7	1,02
2	60,00 – 89,99	Good	471	68,76
3	30,00 – 59,99	Less Good	183	26,72
4	0,00 – 29,99	Not Good	6	0,88
Total			685	100,00

Table 8 shows the ability of students to answer questions on the clarity indicator where the ability of students to answer on this indicator is in the good category seen from the percentage obtained above 50% with the achievement of students who can explain the argument so that there are no errors in concluding reaching 411 (60.00%), and there are 3 (0.33%) students in the very good category. As for the category of less good as many as 242 (35.33%) and 4 (0.73%) in the category of not good.

Table 8: Critical Thinking Ability of Class XI High School Biology Students in Makassar City Based on Clarity Indicator

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	3	0,44
2	60,00 – 89,99	Good	411	60,00
3	30,00 – 59,99	Less Good	242	35,33
4	0,00 – 29,99	Not Good	4	0,73
Total			685	100,00

The ability of students to answer questions on the overview indicator can be seen in Table 9. The critical thinking ability

of students in this category is in the poor category because the ability of students to review something that has been found is considered to be lacking, it can be proven in the percentage of research results obtained below 50%, namely only 317 (46.28%) students who are categorized as good and 20 (2.92%) in the very good category. As for the less good category, there are 319 (46.57%) and 1 (0.15%) in the not good category.

Table 9: Critical Thinking Ability of High School Biology Students in Grade XI in Makassar City Based on the Overview Indicator.

No	Value Range	Category	Total Students	Percent
1	90,00 – 100,00	Very good	20	2,92
2	60,00 – 89,99	Good	317	46,28
3	30,00 – 59,99	Less Good	319	46,57
4	0,00 – 29,99	Not Good	1	0,15
Total			685	100,00

4. Discussion

Critical thinking is an important skill that every high school student should have. It involves the ability to logically analyze, assess, and structure information and critically question thoughts and beliefs. However, despite the importance of critical thinking, many high school students still experience difficulties in developing this skill. The research results are in Table 1. Shows that there are still 298 (43.50%) students whose critical thinking skills are not good and 9 (1.31%) students whose critical thinking skills are not good. Critical thinking skills are influenced by many factors. One of the main reasons why high school students have difficulty in critical thinking is a curriculum that is too focused on academic achievement. The education system often emphasizes mastery of subject matter and national standardized tests. As a result, students are more likely to prioritize memorizing facts over developing critical thinking skills. An overly rigorous curriculum can override the learning of critical thinking, leaving students poorly trained in solving complex problems or developing strong arguments [1]. In addition, when students are not given opportunities to practice critical thinking in the classroom environment, their ability to do so is hindered [19]. Many teachers may focus more on delivering material than building students' critical thinking skills. Limited time and resources can also be an obstacle in providing adequate critical thinking training.

In addition, to foster students' critical thinking skills, challenges are needed to encourage critical thinking. These can be thinking challenges, debates, or project tasks that encourage students to investigate issues more deeply and problem-solve. Without this kind of encouragement, students may not feel the need to develop critical thinking. This is in line with the results of research that the application of project-based learning can improve students' critical thinking skills [23],[25]. The application of problem-based learning improves students' critical thinking skills [21], [22], [25].

The implementation of the 2013 Curriculum according to

Permendikbud No. 22 of 2016 concerning Process Standards uses 3 (three) learning models that are expected to shape scientific, and social behavior and develop curiosity and critical thinking skills, namely (1) the Discovery/Inquiry Learning model, (2) the Problem-based Learning (PBL) model, and (3) the Project-based Learning (PJBL) model. Meanwhile, the recommended learning models for implementing the independent curriculum are Problem-Based Learning (PBL), Project Based Learning (PJBL), Discovery Learning (DL), and Inquiry Learning (IL). The four models can foster 4C skills, namely collaborative, creative, critical thinking, and communication, or build good multi-directional communication in the learning process [47]. The implementation of the two curricula should have been able to lead students to be able to think critically well.

Of the six indicators of critical., thinking of Class XI high school biology students in Makassar City based on modified FRISCO indicators (Table 3), the ability to make inferences and overviews is still classified as poor. One of the main reasons why students have difficulty making conclusions and overviews is the lack of understanding of the material they learn. Before being able to make good conclusions, students must understand the essence of the material. If they just memorize the facts without really understanding them, they will have difficulty extracting relevant information for the conclusion. Making good inferences requires strong critical thinking skills. Students need to be able to analyze the information they have, identify patterns or relationships, and structure it into a logical conclusion. Many students do not have these skills, and this makes it difficult for them when trying to make appropriate inferences. As with any skill, making inferences and overviews requires consistent practice. Unfortunately, many students are given little opportunity to practice. Educational curricula that focus on standardized tests and memorization often neglect the development of these critical thinking skills. As a result, students do not have enough time to hone their inference and overview skills.

Table 4 shows the critical thinking skills of students based on the focus indicator. Based on this indicator out of 685 students, 499 (72.85%) students were in a good category, and 14 (2.04%) were in the excellent category with an average value of 6.55 ± 1.13 . Table 5 with critical thinking indicators, namely Reason, shows a good category of 485 (70.80%) and very good as many as 13 (1.90%) with an average value of 6.34 ± 1.09 . Table 7 with the Situation indicator shows a good category of 471 (68.76%) and very good as many as 7 (1.02%). These results may be achieved if teachers apply innovative learning such as project-based learning, problem-based learning, discovery-based learning, collaborative learning, and case-based learning [26],[29]. In Project-Based Learning: students are given real projects or complex tasks that require identifying problems before they can solve them. They must identify problems, conduct research, and design creative solutions. Problem-Based Learning places students in a situation where they are faced with a complex and realistic problem. They must then work towards a solution while identifying the problem and seeking relevant information, and Inquiry-based Learning

encourages students to question, investigate, and seek answers to problems or questions they have. Students learn by identifying problems and formulating relevant questions.

5. Conclusion

Based on data analysis, it can be concluded that the number of high school students who have good and very good critical thinking skills > 50% of the six modified FRISCO critical thinking indicators there are four indicators namely focus, reason, situation, clarity with an average value in the good category and two indicators with an average value in the less good category, namely inference and overview. The number of students with the ability to identify problems (focus) that are in the good and very good categories is 513 (74.89%). The number of learners with the ability to provide logical (reason) who are in the good and very good categories is 498 (72.70%). The number of learners with the ability to draw (inference) that are in the good and very good categories is 343 (50.07). The number of learners with the ability to compare the actual (situation) which is in the good and very good category is 478 (69.78). The number of learners with the clarity of terms in the good and excellent categories was 414 (60.44). The number of learners who can check something that has been determined (overview) which is in the good and very good category is 337 (49.20).

Acknowledgment

I am grateful for the financial assistance from the Directorate General of Higher Education, Ministry of Education (DRTPM) to carry out this research.

References

- [1] Ariyana, Y., Pudjiastuti, A., Bestary, R., and Zamroni. Handbook of Learning Oriented to Higher Thinking Skills. Directorate General, Teachers, and Education Personnel, Ministry of Education and Culture, 2018.
- [2] Urban, K.K. Assessing Creativity: the Test for Creative Thinking- Drawing Production The Concept, Application, Evaluation, and International Studies. Journal of Psychology Science, vol. 46, no. 3, pp. 387–397, 2004.
- [3] Riyadi, U. Inquiry Learning Model with Laboratory Activities to Improve Students' Critical Thinking Skills on the Subject of Static Fluids. Department of Science Education, Semarang State University, 2008.
- [4] Lim, Leonel. Beyond logic and argument analysis: Critical thinking, everyday problems and democratic deliberation in Cambridge International Examinations' Thinking Skills curriculum. Journal., of Curriculum Studies, vol 43, no. 6, pp. 783-807, 2011.
- [5] Reta, I Ketut. The Influence of the Problem-Based Learning Model on Critical Thinking Skills Given Students' Cognitive Style. Science Education Department, Ganesha Education University Postgraduate Program, 2012.
- [6] Andini, A. R., & Qomariyah, N. Validation of Flipbook Type E-Book Material on the Human Digestive System Based on PBL to Train Critical Thinking Skills of High School Students. Berkala, a Scientific Biology Education (BioEdu), vol. 11, no. 2, pp. 330–340, 2022.

- [7] Mehta, S., & Al.-Mahrooqi, R. Can Think to be Taught Tinking Critical Thinking and Writing in an EFL Context. *RELC Journal*, vol 46, No. 1, pp.23-36, 2015.
- [8] Eggen, P. dan Kauchak, D. *Learning Strategies and Models for Teaching Content and Thinking Skills Sixth Edition* (Translation by Satrio Wahono). Jakarta: Indeks, 2012.
- [9] Ennis, Robert H. *Critical Thinking Assessment. Theory Into Practice*, vol. 32, no.3, pp. 179-186, 1993.
- [10] Adnan, Mulbar, U., Sugiarti & Bahri. A. Scientific Literacy Skills of Students: Problem of Biology Teaching in Junior High School in South Sulawesi, Indonesia. *International Journal of Instruction*, vol. 14, no. 3, pp. 847-860, 2021.
- [11] Adnan, Nurhayati B, Saleh AR. Study of Biological Cognitive Abilities of Makassar 5 Public High School Students. In: *Proceedings of the National Seminar, Research Results from LP2M-Makassar State University*, pp. 17-28, 2022.
- [12] Browne, M. N., & Freeman, K. E. *Distinguishing Features of Critical Thinking Classrooms. Teaching in Higher Education*, 2000.
- [13] Muis A, Adnan, Laumma I, Nurjannah. The Development of Critical Thinking Inventory Instrument for Biology Department Students. In: *Proceedings of ICMSTEA: International Conference on Mathematics, Science, Technology, Education, and their Applications*, pp. 234-239, 2016.
- [14] Adnan, Mulbar, U., Sugiarti & Bahri. A. Biology Science Literacy of Junior High School Students in South Sulawesi, Indonesia. In: *Proceedings Journal of Physics: Conference Series*, pp. 1- 8, 2019.
- [15] Arend, B. Encouraging Critical., Thinking in Online Threaded Discussions. *The Journal., of Educators [Online]*. 6 (1), 1-23. Available from: <http://www.thejeo.com/Archives/Volume6Number1/Ar endpaper>. [Accessed: March 1, 2009].
- [16] Suryanti., Arifin, I.S.Z. and Baginda. The Application of Inquiry Learning to Train Critical., Thinking Skills on Light Material of Primary School Students. *Journal of Physics*, 2018.
- [17] Oktaviah, R., Mawarda, N.R and Reza, M. A. Inquiry-based teaching to develop EFL students' Critical thinking in reading comprehension. *Education of English as Foreign Language Journal*, vol, 4 no.1, pp. 44-51, 2021.
- [18] Arsal., Z. The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education*, 2017.
- [19] Aswan, D.M., Lufri, L. and Sumarmin, R. Influence of Problem-Based Learning on Critical Thinking Skills and Competence Class VIII SMPN 1 Gunuang Omeh, 2016/2017. *Materials Science and Engineering*, 2023.
- [20] Nicole, P.F.B and Andrade, R. R. Problem-Based Learning Strategies and Critical Thinking Skills Among Pre-Service Teachers. *International Journal of Science, Technology, Engineering and Mathematics* vol.2, no. 2, pp. 1-28, 2022.
- [21] Riwanto, N., Ratmaningsih, N. and Iqbal., M. Improve Student's Critical Thinking Through Problem-Based Learning Model in Social Studies Learning. *International Journal Pedagogy of Social Studies*, vol. 4, no. 2, pp.1-6, 2019.
- [22] Yulia, Z and Salirawati. The Effect of Problem-Based Learning on Students' Critical Thinking Ability and Scientific Attitude. *Journal of Research in Science Education*, vol. 9, no. 6, pp. 4211–4217, 2023.
- [23] Fitria, T and Tahrun. Improving Students' Critical., Thinking Skills through Project-Based Learning (PBL) in General., English for Pre Intermediate 4 Class in LB LIA Palembang: A Classroom Action Research. *Jurnal Pendidikan Tambusai*, vol. 5, no.2, pp. 4907-4910, 2021.
- [24] Bani, H.I and Khataibeh, A. The Effect of Using Project-Based Learning on Improving the Critical Thinking among Upper Basic Students from Teachers' Perspectives. *Pegem Journal of Education and Instruction*, vol. 11, no. 2, pp. 52-57. 2021.
- [25] Lusiana, N., Herwin, and Fatmawati. PBL and PJBL Comparative Study on Critical Thinking Ability in Blended Learning. *International Journal of Elementary Education*, vol.6, no.3, pp. 682-690, 2022.
- [26] Widarbowo, D., Nofirman., Jasiah., Surur, M and Diah, E.A. Meta-Analysis Study for the Use of Project Based Learning Models in Teaching and Learning Activities. *Journal on Education*, vol. 5, no. 4, pp. 16306-16311, 2023.
- [27] Dwi M. S., Joyoatmojo, S., Kusuma, D.W, and Bayu, K. S. Developing Critical.Thinking Skills through the Collaboration of Jigsaw Model with Problem-Based Learning Model. *International Journal of Instruction*, vol. 12, no. 1, pp. 1077-1094, 2019.
- [28] Pujiati, A. Exploring The Connection Between Collaborative Learning and Students' Critical Thinking and Social Adaptation Skills, 2023.
- [29] Al fiandra., Yusuf, S., Baran, I., and Safitri, S. Improving Students' Critical Thinking Skills Through Case Based Learning Oriented Textbook. *Jurnal Penelitian dan Pengem-bangan Pendidikan*, vol 6, no. 3, pp. 440-449, 2022.
- [30] Ghina, A. R., and Nani, H. Case-based learning in improving critical thinking skill on reading comprehension for the eleven grade students at SMAN 2 Semarang. *Jurnal Ilmiah Sultan Agung*, 2022.
- [31] Rabea, O., Islam, A. N and Ali, I.H.A. The Role of Using Case Studies Method in Im-proving Students' Critical., Thinking Skills in Higher Education. *International Journal of Higher Education*, vol. 9, no. 2, 297-308, 2020.
- [32] Cicchino, M. I. Using Game-Based Learning to Foster Critical Thinking in Student Dis-course. *Interdisciplinary Journal of Problem-Based Learning*, vol. 9, no. 2, pp. 1541-5015, 2015.
- [33] Mau, W., C., Yunhuo, C., Ming, M. C. and Lei, H. Effects of Game-Based Learning on Students' Critical Thinking: A Meta-Analysis. *Journal of Educational Computing*. Vol. 59, no. 8, pp.1682-1708, 2022.
- [34] Istiqamah, A. I., Ismail, W., Syahriani., and Syamsul. Game-Based Learning Media and Its Effect on Students' Learning Achievement. *Journal Pena Sains*, vol. 10, no.1, pp. 34-40, 2023.
- [35] Sahamid, H. Developing critical., thinking through Socratic Questioning: An Action Research Study.

International Journal of Education & Literacy Studies, vol, 4 no. 3, pp. 62-72, 2016.

- [36] Roudotun, V.N. Socratic Questioning to Promote the Students' Critical., Thinking in Reading Explanation Text. *Journal Retain*, vol. 8, no. 2, pp. 49-56, 2020.
- [37] Poetri, A.L., Emaliana, I and Nany, I.K. Improving Learners' Critical., Thinking and Learning Engagement Through Socratic Questioning in Nominal Group Technique. *Studies in English Language and Education*, vol 9, no. 2, 705-723, 2021.
- [38] Dika, E.T.P., Dwi, H.S., and Asnul, D.M. Utilizing Web-Based Learning as 21st Century Learning Media for Vocational., Education. *International Journal of Engineering & Technology*, vol.7.no.4, pp. 157-160, 2018.
- [39] Valensia, E. A and Dwi, H.S. The Development of Mobile Base Interactive Learning Multimedia for Critical Thinking Improvement. *Journal of Educational Science and Technology*, vol.7,no.2, pp. 174-187, 2021.
- [40] Rahayu, S., Isnaeni, W and Masturi. Critical Thinking Skills and Digital Literacy of High School Students in Science Learning Using E-Learning with STEM Vision. *Journal of Innovative Science Education*, vol. 11, no. 3, pp. 347-361, 2022.
- [41] Amaningsih, A., Amilia, R.A., and Tamara, A.A. Critical Thinking Based Interactive Learning Media for Basic Mechanical Engineering. *Jurnal Pendidikan Teknologi dan Kejuruan*, vol. 27, no. 2, pp 146-156. 2021.
- [42] Cindiati, M., CLaudianingrum, H., Azhaar, J.R., Kuswarini, P.S and Diella, D. The Cor-relation Between Critical Thinking Skills and The Learning Outcomes on Musculoskele-tal System. *Jurnal Pendidikan Biologi*, vol.14, no.2, pp. 122-133, 2021.
- [43] Putu, P.P.S., Gisti, I.P.S., Gusti, I.P. S. Students' Critical Thinking Skills in Solving Mathematical Problems: Systematic Literature Review. *Indonesian Journal Of Educational Research and Review*, vol.6, no.1, 2023.
- [44] Tanti., Kurniwan, D.A. Kuswanto., Utami, W., Wardhana, I. Science Process Skills and Critical Thinking in Science: Urban and Rural Disparity. *Jurnal Pendidikan IPA Indonesia*, vol.9, no.4, pp. 489-498, 2020.
- [45] Setiawati, H. and Duran, A.C. Empowering Critical., Thinking Skills of The Students Having Different Academic Ability in Biology Learning of Senior High School through PQ4R - TPS Strategy. *The International Journal of Social Sciences and Humanities Invention*, vol. 4, no. 5, 3521-3526, 2017.
- [46] Arends, R.I. *Learning to Teach*. New York: McGraw-Hill Companies, Inc., 2012.
- [47] Rosidi, A. *Learning Models Suitable for the Independent Curriculum*. [Online]. Available from: <https://www.indotimes.co.id/opini/model-pembelahan-yang-suitable-for-kurikulum-merdeka>. [Accessed: May. 10, 2023].

Author Profile



Rifka Almunawarah is a student in the Graduate Program, at Makassar State University, Indonesia. She also conducted biology education research measuring critical thinking skills.



Adnanis a lecturer at the Department of Biology, Faculty of Mathematics and Natural Sciences, Makassar State University, Indonesia State University of Makassar, Indonesia. His research interests in biology education include: learning models, constructivist abilities, metacognitive skills, critical and creative thinking, and student attitudes



Arsad Bahri is a lecturer in the Biology Department, Faculty of Mathematics and Sciences, Universitas Negeri Makassar, Indonesia. His research interests include biology education, critical thinking, metacognitive skills, and student attitudes