International Conference on Biology Education, Natural Science, and Technology
Vol. 3 No. 1 (2025)
E-ISSN : 3026-5428

Analysis of The Emergence of Critical Thinking in Biology Teaching Modules on Cell Material for Grade XI High School Students In The Surakarta Residency

Winda Widyaningrum, Hariyatmi*
Biology Education Department, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. A. Yani Street, Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
*Corresponding Author. E-mail address: hariyatmi@ums.ac.id

KEYWORDS:
Biology
Content analysis
Critical Thinking
High School
Teaching module

© 2025 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

21st century education emphasizes the development of six core skills (6Cs): critical thinking, collaboration, communication, creativity, culture, and connectivity. In biology education, deep understanding and analytical thinking is crucial, yet challenges such as time constraints, a dense curriculum, and insufficient support hinder the integration of critical thinking. This study aims to analyze the presence of critical thinking indicators in grade XI Biology teaching module on cell material across high schools in the Surakarta Residency. A descriptive qualitative method was used in this study. Data were collected from five teaching modules each provided by selected biology teachers from public, private and Muhammadiyah high schools, using documentation and interviews. Result show that the most frequency appearing critical thinking indicator was "providing simple explanations" (64.28%) at Muhammadiyah schools, while the least frequent was "strategies and tactics" (3.57%). These findings offer valuable insights for biology teachers in improving their instructional design to better foster critical thinking.

1. INTRODUCTION

21st century skills, also known 6Cs, include: critical thinking, collaboration, communication, creativity, culture, and connectivity. [1]. Among these, critical thinking particularly vital as it enables individuals to solve problems, determine causes, think logically about something, generate solutions, and draw conclusions [2]. According to research [3] critical thinking is a skill in the intellectual process that involves activities and skills in various aspects, including conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from or generated by observation, experience, reflection, reasoning, or communication, as problem solving and decision making. Critical thinking skills are very important for teachers to apply in school learning, one of which is in Biology lessons [4]. Biology is a branch of science that studies living things, the environment, and the relationship between the two [5]. One of the subtopics in biology is cells, which are the smallest units of living organisms capable of performing life functions. They are called the smallest units because they cannot be divided any further. Cells can perform all life processes such as respiration, digestion, decomposition, synthesis, reproduction through cell division, and responding to stimuli [6].

The essence of biology, which encompasses processes, products, attitudes, and technology, is best learned by developing critical thinking skills. [7]. According to research [8], the biological nature of the subject, which requires deep understanding and critical analysis, often poses challenges when applied by teachers. These challenges include time constraints, a dense

curriculum, and a lack of support for integrating critical thinking into learning. This is reflected in the teaching modules developed by teachers, which demonstrate their ability to design learning that supports interaction and understanding. [9].

Based on research [10] reported that the ability of biology teachers at SMAN 1 Singorojo to develop students' critical thinking skills was good, but according to research [11] The PCK abilities of science teachers at Jatisrono State Junior High School are very good. The ability of high school biology teachers in Sragen Regency to develop teaching modules for the 2022/2023 academic year is considered adequate. [12]. Similarly, it was also mentioned that the ability of biology teachers at MAN Surakarta to develop students' critical thinking skills was very poor. [13]. [14] states that the critical thinking and communication skills of grade XI students at Widorokandang High School are relatively low.

Teachers' critical thinking skills in terms of lesson planning are still low, due to limited facilities and infrastructure. Each teacher is able to develop critical thinking skills according to his teaching experience. [15]. The realization of teachers' critical thinking in teaching modules needs to be improved to improve students' critical thinking skills, because some schools have not shown the required indicators This study aims to analyze how critical thinking is realized in teaching modules on cell material used by grade XI biology teachers in the Surakarta Residency.

2. MATERIALS AND METHODS

2.1. Type of research

This research used descriptive qualitative method, providing an objective description of the emergence of critical thinking indicators in Grade XI biology teaching modules on cell material within the Surakarta Residency for the 2024/2025 academic year.

2.2. Population, Sample and Sampling

The population of this study was 15 biology teachers of grade XI from all 3 types of high schools (public, private, and Muhammadiyah) in Surakarta Residency. Using purposive sampling, one teacher from each type of school was selected. Each was given five learning modules focusing on cell material.

2.3. Data Collection

Data were collected through documentation (soft and hard copies of teaching modules) and semi-structured interviews with participating teachers.

Table 1. Data, Data Sources, and Collection Techniques

Data	Data Sources	Data Collection Techniques	Instrument
Critical thinking	Grade XI biology teaching modules	Documentation, interviews	Critical thinking identification sheet (Appendix 1)

2.4. Research Procedures

The study was conducted in two stages. The first stage involved developing and testing instruments to identify critical thinking indicators. The second stage included collecting and analyzing the teaching modules using the validated instrument.

2.5. Data Analysis

Data were systematically tabulated and organized into simple tables to facilitate the analysis of critical thinking indicators. Descriptive qualitative methods were used to assess the frequency and nature of critical thinking elements in the modules.

3. RESULTS AND DISCUSSION

The research data includes the emergence of critical thinking skills indicators among 11th grade high school teachers in the Surakarta Residency for the 2024/2025 academic year in teaching cell material, as presented in Table 3. The findings highlight the distribution of critical thinking indicators across public, private, and Muhammadiyah high schools. The most frequent indicator was "providing simple explanations" (64.28%) in Muhammadiyah schools, and the least was "strategies and tactics" (3.57%). This shows that teachers plan more critical thinking indicators by providing simple explanations that include: focusing questions, analyzing arguments, and asking and answering questions about an explanation. [16]. The benefits of implementing these indicators include increased student understanding and engagement. For further development, teacher training on critical thinking strategies, integration of indicators in the curriculum, implementation of an evaluation system that provides feedback, and collaboration between teachers from different schools are necessary. These steps are expected to significantly improve students' critical thinking skills.

Table 2. Data Recapitulation of Critical Thinking Appearance (%) Teaching Module Material for Grade XI Classrooms in the Surakarta Residency for the 2024/2025 Academic Year

Critical Thinking	Public High School	Private High School	Muhammadiyah High School	$\bar{x}$
Providing Simple Explanations	22,22	40,90	64,28	42,47
Building basic skills	44,44	22,72	10,71	25,96
Conclusion	11,11	11,36	10,71	11,06
Provide further explanation	14,81	20,45	10,71	15,32
Strategy and tactics	7,40	4,54	3,57	5,17
∑	**100**	**100**	**100**	**100**

A comparison diagram of the emergence of critical thinking indicators in teaching modules is presented in Figure 1. According to the diagram, high school biology teachers exhibit the lowest percentage of critical thinking skills (27%). The development of students' critical thinking abilities is strongly influenced by their teachers, particularly in settings where such skills are not actively fostered. Research consistently demonstrates that implementing effective pedagogical strategies such as Problem-Based Learning (PBL) and Project-Based Learning significantly enhances students' critical thinking skills. Therefore, empowering teachers with these approaches is

essential to cultivating a classroom environment that promotes higher-order thinking and prepares students for complex problem-solving.

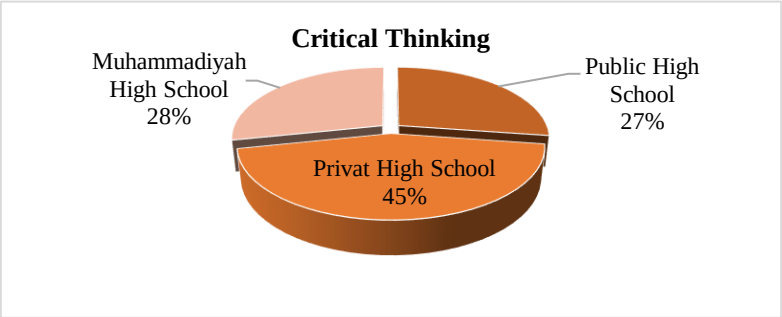

Figure 1. Diagram comparing the emergence of critical thinking in teaching modules

Teachers play a crucial role in creating an engaging learning environment that fosters analytical thinking and problem solving skills. According to [17], teachers must possess strong pedagogical expertise to design effective lessons that actively develop students' critical thinking abilities. These skills are fundamental competencies that should be nurtured from an early age, as they enable students to analyze information, evaluate arguments, and approach problems systematically. In line with this, [18] emphasizes that teachers are pivotal in shaping students' mindsets and cultivating their critical thinking throughout the learning process. Thus, a teacher's role extends beyond simply delivering content; it involves crafting a dynamic classroom atmosphere and designing activities that actively engage students and stimulate their intellectual curiosity.

A comparative graph illustrating the percentage of critical thinking indicators among public, private, and Muhammadiyah high schools is presented in Figure 2. Analysis of the graph reveal distinct patterns in the development of critical thinking skills across these three types of high schools in the Surakarta Residency. Notably, the indicator "Providing Simple Explanations" appears most frequently in Muhammadiyah high schools, with an occurrence rate of 64.28%. In contrast, the "Strategies and Tactics" indicator in the same school type shows the lowest frequency, at just 3.57%. Supporting these findings, a study of junior high school students in Surakarta, the average critical thinking skill was 46.87%, categorized as low [19]. Another study reported reasoning skills at 57% and reflection at 70.74%, indicating variability in critical thinking abilities across different educational contexts. [20].

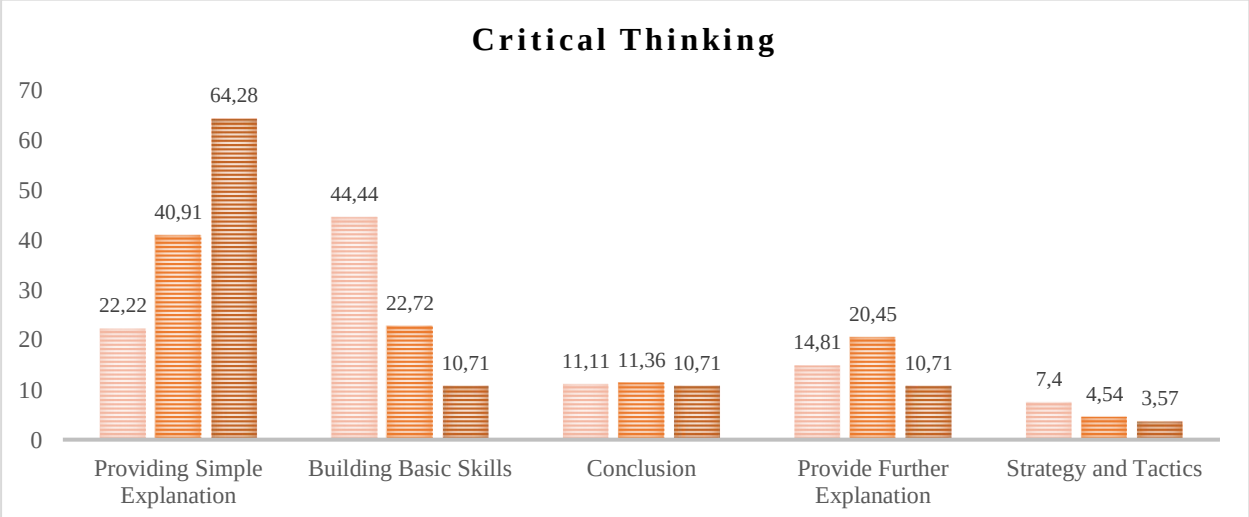

Figure 2. Comparison Chart (%) of Critical Thinking Indicators (Public High Schools, Private High Schools, Muhammadiyah High Schools).

3.1. Providing Simple Explanation

Figure 3 presents a comparison of the percentage occurrence of the indicator Providing Simple Explanations across three types of senior high schools: public, private, and Muhammadiyah. The biology teacher training module revealed significant differences, with Muhammadiyah senior high schools demonstrating the highest occurrence at 64.28%, followed by private schools at 40.90%, and public schools at 22.22%. This data indicates that all school groups consistently emphasize the importance of this indicator in their teaching practices. These findings align with previous research [21], which confirms that providing simple explanations is a simple indicator that teachers must master in developing students' critical thinking skills. Moreover, the high frequency of this indicator suggests that students possess a solid capacity to identify basic problems and comprehend essential information. This underscores the critical role of the diagnostic stage in measuring critical thinking skills. Through this indicator, teachers can evaluate students' foundational understanding, which is essential for progressing to more advanced analytical processes [22].

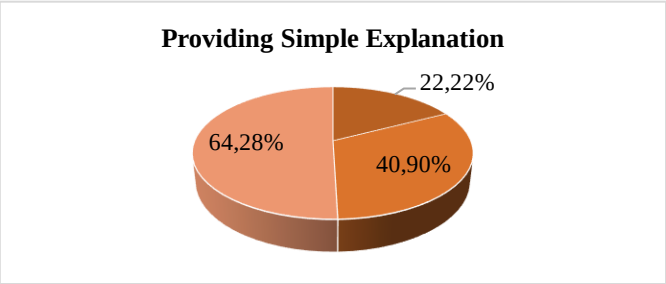

Figure 3. Comparison Diagram of the Appearance (%) of Indicators Providing Simple Explanations (Public High Schools, Private High Schools, and Muhammadiyah High Schools)

The analysis of the emergence of the providing simple explanations indicator in public, private, and Muhammadiyah high schools presented in Figures 4, 5, and 6.

2. ***Problem statement*** Teachers guide students to identify as many problems as possible by asking **questions** about what they want to know from the information provided previously. (Sub-element: **Asking Questions** in the **Critical Thinking Dimension**)	The role of teachers in providing simple explanations encompasses several key functions that enhance students' understanding of plant biology. teachers introduce fundamental concepts, deliver clear information, and stimulate classroom discussions, all aimed at deepening students' comprehension.
Figure 4. Example of Indicator Appearance Providing Simple Explanations in the Cell Teaching Module at Public High Schools	
Step 1. Stimulus a. Teacher asks what a cell is. How were cells discovered? What are the sizes and types of cells? What are the components of cells? b. Teachers present diagrams of cell discovery and theories about cells from scientists. c. The teacher presents **your knowledge test** from the biology book for high school/MA elective subjects for grade XI from Erlangga Publishing Company, pages 3-4 **Step 2. Problem Identification** a. Students are asked to ask as many questions as possible related to the history of the discovery of cells and theories about cells.	The role of teachers act as facilitators by fostering an interactive learning environment that encourages students to think analytically and critically about the material
Figure 5. Example of Indicator Appearance Providing Simple Explanations in the Cell Teaching Module at Private High Schools	

critical thinking - Providing opportunities for students to identify and then create as many questions as possible related to the images presented, which will be answered through learning activities, particularly on the subject of animal cells and plant cells. *(Process and product differentiation)*	The role of teachers serve as mentors who promote active learning, guiding students to analyze information thoroughly and develop advanced questioning skills.

Figure 6. Example of Indicator Appearance Providing Simple Explanations in the Cell Teaching Module at Muhammadiyah High School

3.2. Building Basic Skills

Figure 7 illustrates a comparison of the percentage occurrence of the Building Basic Skills indicator across three types of senior high schools: public, private, and Muhammadiyah. The data shows that this indicator appears most frequently in public high schools (44.44%), followed by private high schools (22.72%), and Muhammadiyah high schools (10.71%). The Building Basic Skills indicator represents intermediate-level critical thinking skills that are adaptable to various learning contexts. The implementation of this indicator is more profound when carried out through practical activities, because practical learning provides an optimal platform for students to apply basic skills in more complex learning situations. Interviews with high school biology teachers confirmed that during practical lessons, students actively engaged in observations, such as directly examining cell structures. High school biology teachers also emphasized that their years of professional experience had optimized their ability to facilitate the development of students' basic skills. This finding aligns with previous research [23] which highlights that successfully fostering basic skills requires teachers' strong commitment and sufficient time for comprehensive planning, designing, implementation, and evaluation of learning activities.

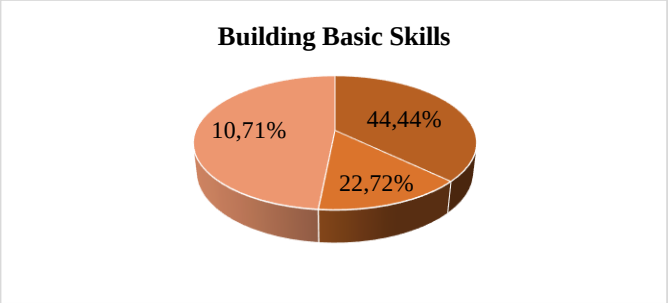

Figure 7. Comparison Diagram of the Appearance (%) of Indicators Providing Simple Explanations (Public High Schools, Private High Schools, and Muhammadiyah High Schools)

The analysis of the Building Basic Skills indicator in public, private, and Muhammadiyah high schools presented in Figures 8, 9, and 10.

CORE LEARNING (100 minutes) 1. Students conduct cell observation experiments (prepare cell samples, such as cork cells, oral cavity epithelium, and onion epidermis, then observe them under a microscope) observing	The role of teachers in fostering these skills by acting as guides who create an interactive learning environment by making cell preparations, encouraging students to analyze the data they obtain, and developing a deeper understanding of cell material.

Figure 8. Example of the appearance of indicators for building basic skills in the teaching module on cell material at a public high school.

Erlangga Publishing, pages 14–15 d. Teachers encourage students to observe prepared/dried specimens using a microscope.	The role of teachers is to develop students skills by guiding them throuh the process of observing specimens encourages students to analyze the material in greater depth.

Figure 9. Example of the appearance of indicators for building basic skills in the teaching module on cell material in private high schools.

4) To observe red blood cells, white blood cells, and blood platelets using a microscope	The role of teachers is to develp students skills by serving as expert guides during blood cell observations. Throuh structured examination of red blood cells, white blood cells, and blood platelets to encourage students to analyze the material in greater depth.

Figure 10. Example of the appearance of indicators for building basic skills in the teaching module on cell material at Muhammadiyah High School.

3.3.Conclusion

A a comparison of the percentage occurrence of the Conclusion indicator across three types of senior high schools: public, private, and Muhammadiyah is presented in Figure 11. The data reveal relatively low but fairly consistent percentages in the Biology teacher teaching module, with private high schools having the highest percentage (11.36%), followed by public high schools (11.11%), and Muhammadiyah high schools (10.71%). The low percentage of this indicator suggests that not all educational institutions have optimally integrated the conclusion component into the teaching modules developed by biology teachers. According to research [22] conclusion indicators are essential, requiring students to synthesize facts and information to make well-founded decisions through in-depth logical analysis. This finding is an important reflection for teachers because the low average occurrence of conclusion indicators can be used as an evaluative indicator to assess the effectiveness of teachers in developing high-level critical thinking skills, particularly in the aspect of drawing conclusions from valid argument data. Consequently, there is a pressing need for systematic efforts to strengthen the integration of summarizing and conclusion-drawing skills within biology instruction.

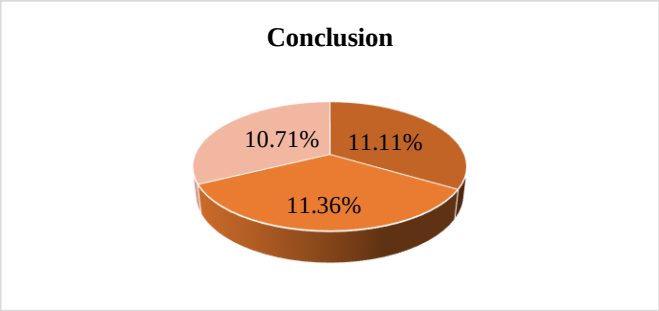

Figure 11. Comparison Diagram of the Appearance (%) of Conclusion Indicators (Public High Schools, Private High Schools, and Muhammadiyah High Schools)

The analysis of the presece of conclusion indicators across different types of high schools including public, private, and Muhammadiyah presented in Figures 12, 13, and 14.

Making conclusions/generalizations Teachers and students write conclusions related to the concept of cells based on the history of cell discovery and various cell organelles through literacy	The role of teachers in the conclusion indicator as facilitators is to ask students to formulate conclusions, by promting students to analyze the information they have learned and consider the relationships between various concepts.

Figure 12. Example of the appearance of conclusion indicators in the teaching module on cell material at a public high school.

Generalization - Teachers guide students in drawing conclusions. End of lesson (30 minutes)	The role of teachers in the conclusion indicator is to guide students in drawing conclusions and fostering a deeper and more integrated understanding of cells and their bioprocesses.
Figure 13. Example of the appearance of conclusion indicators in the teaching module on cell material at a private high school.	
2. The teacher helps students draw conclusions about animal cells and plant cells 3. Students take a quiz	The role of teachers in the conclusion indicator is to facilitate students in drawing conclusions and fostering a deeper and more integrated understanding of both animal and plant cells.
Figure 14. Example of the appearance of conclusion indicators in the cell teaching module at Muhammadiyah High School.	

3.4. Providing Further Explanation

Figure 15 present a comparison of the percentage of providing further explanation indicator across three types of high schools: public, private, and Muhammadiyah. Notably, the indicator of providing further explanation in the Biology teacher teaching module is highest in the Private High School group (20.45%), Public High School (14.81%), and Muhammadiyah High School (10.71%). This skill represents a high-level critical thinking ability, requiring student to move beyond basic comprehensive analysis and in-depth conceptual development. In the other words, students must not only understand basic information, but also to be able to provide more complex explanations. This finding alings with research [22] which confirms that the frequency of this indicator reflects students' capacity to thoroughly explore and express their analytical insights. The relatively low occurence of this indicator compared to others a valuable opportunity for teachers to refine and innovate their teaching strategies. Consequently, teachers can better foster students deeper analytical thinking and enhance their argumentation skills. This condition requires a more creative and effective pedagogical approach to improve the quality of students' conceptual elaboration in biology learning.

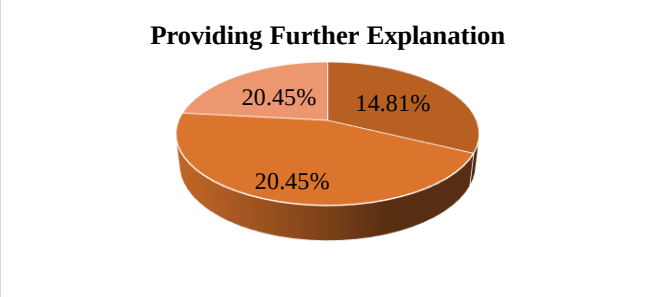

Figure 15. Comparison Diagram of the Appearance (%) of Indicators Providing Further Explanation (Public High Schools, Private High Schools, and Muhammadiyah High Schools)

The analysis of the occurrence of the providing further explanation indicator across three types of high schools: public, private, and Muhammadiyah presented in Figures 16, 17, and 18.

c. Teachers provide opportunities for students to identify problems related to cell organelles.	Teachers play a crucial role as facilitators in promoting the providing further explanation indicator by fostering a dynamic learning environment, encouraging students to explore and understand issues related to cell organelles in greater insight.
Figure 16. Example of Indicator Appearance Providing Further Explanation in the Cell Teaching Module at State Senior High School	

The teacher gives students the opportunity to identify whether all animal cells have the same organelles.	The role of teachers in the indicators provides further explanation for students to explore and develop a deeper understanding issues related to cell organelles in animal cells in greater depth.

Figure 17. Example of Indicator Appearance Providing Further Explanation in the Cell Material Teaching Module at Private High Schools

Students identify whether interactions between cells are limited to direct interactions, or whether there are more complex and indirect interactions.	The role of teachers in the indicators provides further explanation by encouraging students to think critically and analyze how interactions within the cells can affect its function and behavior within a broader biological context.

Figure 18. Example of Indicator Appearance Providing Further Explanation in the Cell Teaching Module at Muhammadiyah High School

3.5. Strategy and Tactics

Figure 19 present a comparison of the occurrence of strategy and tactics indicators across three types of high schools: public, private, and Muhammadiyah. Notably, strategy and tactic indicators are the least common indicators in the teaching modules for biology teachers, appearing in only 7.40% of the public high schools modules, 4.54% of private high school modules, and 3.57% of Muhammadiyah high school modules. These indicators show high-level critical thinking skills, because developing effective strategies and tactics requires thorough investigation and complicated evaluation of the current situation [24]. The relatively low of these indicators, particulary in Muhammadiyah high schools, reveals a significant gap in fostering advanced critical thinking among students. To adress this, teachers must constantly improve their expertise and keep up with contemporary educational innovations. This ensures that the educational content and activities delivered to students are relevant and effective. One practical approach to enhance the presence of strategy and tactic indicators is incorporating case studies, role-playing, and collaborative projects into curriculum. This aligns with research [22] which states the importance of these indicators in developing students' problem-solving abilities. If the results are low, teachers can evaluate their teaching approaches and find ways to further encourage strategic thinking, such as through problem-based project exercises.

Figure 19. Comparison Diagram of the Appearance (%) of Indicators Providing Further Explanation (Public High Schools, Private High Schools, and Muhammadiyah High Schools)

The analysis of the occurrence of strategy and tactics indicators across three types of high schools: public, private, and Muhammadiyah presented in Figures 20, 21, and 22.

Guiding individual and group investigations	a. Assist or monitor students in solving problems b. Encourage students to actively ask questions if they encounter difficulties or do not fully understand the material.	The role of teachers is to implemet effective strategies and tactics that support students and promote active engagement when they face academic challences.

Figure 20. Example of the appearance of strategy and tactic indicators in the teaching module on cell material at a public high school.	
Teachers provide limited assistance if there are students/groups experiencing difficulties.	The role of teachers is to employ diverse instructional strategies and tactics to identify and support students who continue to struggle with previously presented material.
Figure 21. Example of the appearance of strategy and tactic indicators in the teaching module on cell material at a private high school.	
Teachers accompany students and provide limited assistance if there are difficulties in conducting observations	The role of teachers is to implement effective strategies and tactics that assist students in conducting accurate and meaningful observations.
Figure 22. Example of the appearance of strategy and tactic indicators in the teaching module on cell material at Muhammadiyah High School.	

4. CONCLUSIONS

Based on the results of the research and discussion, it can be concluded that critical thinking emerged in the biology teaching module on cell material for grade XI high school students in the Surakarta Residency for the 2024/2025 academic year. The most frequently appearing critical thinking indicator in the teaching module is the indicator of providing simple explanations (64.28%), while the least frequently appearing indicator is in strategies and tactics (3.57%).

5. ACKNOWLEDGMENTS

The author would like to thank the biology teachers at public, private, and Muhammadiyah high schools for their invaluable technical assistance.

6. REFERENCES

[1] M. Anugerahwati, "Integrating the 6Cs of the 21st Century Education into the English Lesson and the School Literacy Movement in Secondary Schools," *KnE Soc. Sci.*, vol. 3, no. 10, p. 165, 2019, doi: 10.18502/kss.v3i10.3898.

[2] I. Fitriani and S. Hidayat, "Analysis of the Need for the Development of PjBL-Based Integrated Ethnoecology e-Learning Modules to Improve Critical and Creative Thinking Skills in Environmental Change," *Indones. J. Educ. Learn.*, vol. 4, no. 2, pp. 721–732, 2024, doi: 10.53299/jppi.v4i2.582.

[3] F. Nuzuliya, "Improve Critical Thinking Skills and Biology Learning Outcomes with a Combination of Guided Inquiry and Numbered Heads Together Models," *Andragogy J. Educ. Learn.*, vol. 4, no. 2, pp. 109–124, 2024, doi: 10.31538/adrg.v4i2.1307.

[4] A. Putri, N. Anas, and M. N. Adlini, "Analysis of Students' 21st Century Skills in Biology Learning," *Warrior J. Character Educ.*, vol. 1, no. 5, pp. 1–17, 2023, [Online]. Available: https://journal.politeknik-pratama.ac.id/index.php/Pendekar/article/view/395

[5] A. M. Jannah, "The Influence of Interpersonal Communication and the Investment and Integrated Services Agency," 2020.

[6] I. H. Husain, H. Mardin, S. Anapia, and C. I. Tamboo, *Cell Structure and Function Based on Augmented Reality*. 2025.

[7] S. Tengah, Setiawati Henny, and Nurhasanah, "Profile of Learning Biology Based on Critical Thinking Skills," vol. 202, no. 2011, pp. 275–285, 2023, doi: 10.18502/kss.v8i10.13452.

[8] N. D. Apriyani and H. Alberida, "The Effect of Problem-Based Learning (PBL) on Students' Argumentation Skills in Biology Learning: Literature Review," *BIOCHEPHY J. Sci. Educ.*, vol. 03, no. 1, pp. 40–48, 2023.

[9] M. H. Aziz, "Media Conglomerates Between Media Convergence and Freedom of Expression," *J. Commun. Sci.*, vol. 16, no. 3, p. 209, 2020, doi: 10.31315/jik.v16i3.3203.

[10] N. Kusuma Dewi and N. Rahayu Utami, "The Effect of Problem-Based Learning Model on Students' Critical Thinking Skills in Excretory System Material," *J. Biol. Educ.*, vol. 5, no. 3, p. 50229, 2016, [Online]. Available: http://journal.unnes.ac.id/sju/index.php/ujbe

[11] M. Arifah and Hariyatmi, "Profile of pedagogical content knowledge (PCK) abilities of science teachers in public junior high schools in Jatisrono," in *National Seminar on Biology and Science Education II*, 2017, pp. 679–685.

[12] A. E. Indriyani and Hariyatmi, "The pedagogical content knowledge (PCK) of high school biology teachers

in Sragen Regency in developing teaching modules for the 2022/2023 academic year," *Biosci. Sci. J. Biol.*, vol. 11, no. 1, pp. 831–838, 2023.

[13] H. Hariyatmi, A. Krisnaningrum, and I. Megatywie, "The Ability of Biology Teachers at MAN Surakarta in Developing Students' Critical Thinking Skills," *4th Natl. Semin. Biol. Sci. Educ.*, no. 2015, pp. 534–544, 2019, [Online]. Available: https://publikasiilmiah.ums.ac.id/xmlui/handle/11617/11367

[14] F. Y. Qodarsih, A. Sunarso, and Y. Utanto, "Analysis of Critical Thinking Ability and Communication Skills of Fourth Grade Students Using the Talking Stick Learning Model Assisted by Poster Media," *Dharmas Educ. J.*, vol. 4, no. 1, pp. 413–425, 2023, doi: 10.56667/dejournal.v4i1.1191.

[15] A. W. Kastutik, "The Pedagogical Content Knowledge (PCK) Ability of Grade VIII Science Teachers in Public Junior High Schools in Sukoharjo Regency in Developing Lesson Plans for the 2013 Curriculum for the 2016/2017 Academic Year," Muhammadiyah University of Surakarta., 2017.

[16] Y. Kurniasari, "The effect of integrated social studies learning on improving critical and meaningful thinking skills in students," Indonesia University of Education, 2014.

[17] L. A. Risandy *et al.*, "The Role of Teachers in Improving Students' Critical Thinking Skills in Grade IV IPAS Lessons at SDN 1 Beluk Widya Dharma University Klaten, Indonesia optimal learning and developing students' critical thinking skills. in improving skills," vol. 1, no. 3, pp. 285–298, 2024.

[18] S. Nurhalizah and O. Hadiyanti, "The Role of Teachers in Fostering Critical Thinking Skills in Science Education," vol. 6, no. 1, pp. 128–142, 2025, doi: 10.37985/murhum.v6i1.1088.

[19] S. N. Hasanah, W. Sunarno, and B. A. Prayitno, "Profile of S tudents ' Critical Thinking Skills in Junior High Schools in Surakarta," in *3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)*, 2020, pp. 570–575.

[20] S. J. Rahayu, Sukarmin, and P. Karyanto, "Analysis of Junior High School Students ' Critical Thinking Skills Profile in Surakarta Analysis of Junior High School Students ' Critical Thinking Skills Profile in Surakarta," in *IOP Conf. Series: Journal of Physics: Conf. Series*, 2019, pp. 1–8. doi: 10.1088/1742-6596/1233/1/012076.

[21] Z. Rizka, Festiyed, Ratnawulan, and D. S. Suherman, "Development of Cooperative Think Talk Write Model Student Worksheets on Global Warming to Facilitate Critical Thinking Skills in High School Students," vol. 8, pp. 42442–42451, 2024.

[22] N. Nurdiyati, M. Novita, and S. Patonah, "Analysis of Students' Critical Thinking Skills in the Development of Differentiated Teaching Modules Oriented towards Education for Sustainable Development in Green Chemistry Materials," vol. 14, no. 1, pp. 167–178, 2025.

[23] N. Sugiharti and Y. Gayatri, "Profile of critical thinking skills of high school students at Muhammadiyah Surabaya in biology learning," vol. 9, no. 1, pp. 34–40, 2021.

[24] U. Salamah and A. N. M. Fauziah, "Implementation of Guided Inquiry to Improve Critical Thinking Skills of Junior High School Students in Science Subjects," *Edu-Sains*, vol. 14, no. 1, pp. 1–12, 2025.