INKUIRI: Jurnal Pendidikan IPA
Volume 14, Number 2, 2025 pp. 227-235
P-ISSN: 2252-7893 | E-ISSN: 2615-7489
DOI: 10.20961/inkuiri.v14i2.101972

Critical Thinking Profile of Chemistry Pre-Service Teachers in Pre-Laboratory Sessions

Devy Lestari[1*], Endah Fitriani Rahayu[1], Rosi Oktiani[2]

[1]*Universitas Negeri Semarang, Indonesia*
[2]*Universitas Pendidikan Indonesia, Indonesia*
[1*]devylestari@mail.unnes.ac.id, [1]endah_danis@mail.unnes.ac.id, [2]rosioktiani@upi.edu

ARTICLE INFO

Article history:
Received 25 March 2025
Revised 17 May 2025
Accepted 23 May 2025
Available online 28 June 2025

Keywords:
critical thinking; pre-service chemistry teachers; pre-laboratory sessions

ABSTRAK

Keterampilan berpikir kritis merupakan kompetensi esensial bagi mahasiswa calon guru kimia, terutama dalam analisis laboratorium. Namun, banyak mahasiswa mengalami kesulitan dalam menerapkannya sebelum eksperimen. Penelitian ini bertujuan untuk menganalisis profil keterampilan berpikir kritis mahasiswa sebelum praktikum identifikasi kation dan anion, dengan mengidentifikasi indikator yang dominan dan perlu ditingkatkan. Penelitian ini menggunakan pendekatan deskriptif kuantitatif dengan purposive sampling, melibatkan 32 mahasiswa Pendidikan Kimia semester 2 dalam mata kuliah Praktikum Kimia Dasar. Instrumen penelitian berupa 40 soal pilihan ganda berbasis indikator berpikir kritis menurut model Ennis. Data diperoleh melalui tes sebelum praktikum dan dianalisis menggunakan statistik deskriptif untuk menentukan distribusi skor dan kategori keterampilan berpikir kritis mahasiswa. Hasil penelitian menunjukkan mayoritas mahasiswa berada dalam kategori cukup (62,50%), sementara 15,62% mencapai kategori baik. Indikator mendefinisikan istilah memiliki skor tertinggi (81.250, kategori baik), sedangkan menganalisis argumen memiliki skor terendah (48.125, kategori kurang). Hal ini menunjukkan bahwa mahasiswa masih mengalami kesulitan dalam mengevaluasi informasi dan menghubungkan teori dengan hasil eksperimen. Penelitian ini memberikan analisis spesifik keterampilan berpikir kritis dalam tahap pra-praktikum, yang belum banyak dikaji sebelumnya. Hasil penelitian ini dapat menjadi dasar pengembangan strategi pembelajaran laboratorium berbasis inkuiri, diskusi reflektif, dan evaluasi argumen ilmiah untuk meningkatkan keterampilan berpikir kritis mahasiswa calon guru kimia.

ABSTRACT

Critical thinking skills are essential for chemistry pre-service teachers, particularly in pre-laboratory sessions. However, many students struggle to apply these skills before conducting experiments. This study aims to analyze the critical thinking profile of chemistry pre-service teachers in pre-laboratory sessions, identifying key indicators that require improvement. This research adopts a quantitative descriptive approach with purposive sampling, involving 32 second-semester Chemistry Education students enrolled in the Basic Chemistry Practicum course. The research instrument consists of 40 multiple-choice questions based on Ennis' critical thinking indicators. Data were collected through pre-laboratory tests and analyzed using descriptive statistics to determine score distribution and categorize students' critical thinking levels. Results show that most students fall into the fairly good category (62.50%), while 15.62% reached the good category. The highest-scoring indicator was defining terms (81.250, good category), while analyzing arguments had the lowest score (48.125, less category). These findings indicate that students struggle with evaluating information and connecting theories to experimental outcomes. This study provides a specific analysis of critical thinking skills in pre-laboratory sessions, an area that remains underexplored. The findings support the need for inquiry-based learning, reflective discussions, and scientific argument evaluation to enhance critical thinking skills in chemistry pre-service teachers.

1. INTRODUCTION

One of the important competencies that must be possessed by prospective chemistry teachers in the 21st century is critical thinking skills (Wahyudi, 2020). These skills not only support academic success, but also serve as a foundation for rational decision-making, complex problem-solving, and adaptation to global changes and

challenges (Hayati & Setiawan, 2022; Sihombing et al., 2020; Daryanes & Son, 2021). Critical thinking plays an important role in strengthening students' understanding of scientific concepts, deepening their ability to formulate evidence-based arguments, and forming a scientific character characterized by a constructive skepticism and a spirit of sustained curiosity. (Sundari & Sarkity, 2021; Zahroh & Yuliani, 2021).

Critical thinking is a skill that students must have in facing the challenges of the world of work in the era of the industrial revolution 4.0 (Sulistyaningrum et al., 2023; Nuraeni et al., 2019). Critical thinking skills have a contribution to science literacy, where critical thinking individuals are better able to understand and apply basic concepts of science in real life (Azrai et al., 2020; Juhji & Mansur, 2020). Students who have good critical thinking skills show higher skills in identifying experimental variables, formulating alternative hypotheses, and evaluating experimental results reflexively (Saraswati & Ducha, 2021; Roviati & Widodo, 2019).

Although critical thinking skills are an essential competency, the findings of a number of studies show that prospective chemistry teacher students still do not show optimal development in mastering these skills. Research by (Anugraheni, 2020) stated that as many as 64.06% of students had difficulty solving problems and 53.13% had difficulty finding alternative solutions. This indicates a gap between theoretical understanding and practical application in the laboratory. This gap is of particular concern, considering that the laboratory is the main space to hone critical thinking skills through experimental activities, scientific discussions, and reflection on observation results (Sundari & Sarkity, 2021).

Strengthening the pre-practicum stage is very important to bridge the gap between theoretical understanding and practical application in the laboratory. This stage should provide an opportunity for students to prepare themselves conceptually before practicing. However, in practice, not a few students take the practicum procedurally, without really evaluating the purpose of the experiment, formulating hypotheses independently, or connecting the results of the experiment with the underlying theory (Sundari & Sarkity, 2021; Roviati & Widodo, 2019). This emphasizes the importance of evaluating students' critical thinking skills at the pre-practicum stage, which has been receiving less attention in chemistry education research.

The Ennis model offers a systematic critical thinking framework, including the ability to focus questions, analyze arguments, consider the credibility of sources, and conclude and make decisions (Yulianti et al., 2020). This model has been widely used in the development of critical thinking skills assessment instruments, including in the form of multiple-choice questions that reflect the complexity of student thinking (Ramalis & Rusdiana, 2015). The results show that the critical thinking skills of prospective chemistry teachers are in the sufficient category, but show development along with increasing levels of education and laboratory experience (Oktariani et al., 2020).

In the education of prospective teachers, critical thinking is a prerequisite for practicing reflective and evidence-based pedagogic skills. Training these skills demands a learning approach that places students at the center of scientific activities, such as Project-Based Learning (PBL) and Inquiry-Based Learning (IBL) (Maros et al., 2023; Duran & Dökme, 2016). A well-designed practicum experience can be an important space for prospective teachers to reflect on their teaching practices in more depth, while strengthening critical thinking skills that are essential in the decision-making process in the classroom (Maaranen & Stenberg, 2017).

Based on this description, this study aims to analyze the critical thinking skills profile of prospective chemistry teacher students in the pre-practicum session, focusing on identifying the most prominent and still low indicators. This research is important to provide an overview of students' cognitive readiness before carrying out experiments, as well as as a basis for developing laboratory learning strategies based on inquiry, reflective discussion, and argumentative evaluation to strengthen critical thinking skills in chemistry education.

2. METHODS

This study uses a quantitative descriptive research design that aims to analyze the critical thinking skill profile of prospective chemistry teacher students in the pre-practicum session. The main focus of this study is to identify the dominant indicators of critical thinking skills and aspects that still need to be strengthened before students carry out laboratory activities. By understanding students' cognitive readiness from the beginning, this study provides an overview of the extent to which students are able to analyze and evaluate experimental data before dealing directly with the tools, materials, and work dynamics of the laboratory.

The research sample was selected using the purposive sampling technique, which is the selection of samples based on certain criteria that are in accordance with the research objectives. The sample consisted of 32 2nd semester students who took the Basic Chemistry Practicum course in the Chemistry Education Study Program. Students in this class have received theoretical learning on the identification of cations and anions before the practicum is implemented, allowing for the evaluation of their critical thinking skills in the pre-practicum stage. The selection of classes taught by the researcher himself aims to ensure uniformity in the learning experience, including the teaching methods, learning resources, and assessment systems used. This uniformity is expected to minimize the influence of external variables, so that the results of the research are more valid and can be controlled properly.

The research instrument used in this study was in the form of 40 multiple-choice questions developed based on the critical thinking skill indicators in the (Ennis, 2018) model. This instrument aims to measure students' abilities in various aspects of critical thinking, which are divided into five main categories, as shown in Table 1.

This section describes how the research was conducted, research design, data collection techniques, instrument development, and data analysis techniques. This section explains how the data was collected/generated and an explanation of how the data was analyzed.

Table 1. Indicators of Critical Thinking Skills (Ennis, 2018)

Aspects	Indicator
Provide a simple explanation	• Focus questions • Analyze arguments • Asking and answering challenging questions
Build basic skills	• Considering the credibility of a source • Observing and considering observation reports
Conclude	• Deducting and considering the results of the deduction • Induce and consider the results of induction, Make and determine the results of the consideration
Provide further explanation	• Defining terms and considering a definition • Identifying assumptions
Setting strategies and tactics	• Defining an Action • Interact with others

Before being used in research, the instrument is validated by expert lecturers in the field of chemistry education and learning assessment to ensure the validity of the content and suitability of the question items, and its reliability is statistically tested to ensure measurement consistency. Data collection was carried out through a pre-practicum test in the form of multiple-choice questions prepared based on critical thinking skill indicators. This test measures students' cognitive readiness before interacting with laboratory experiments, with clear instructions and uniform working times to ensure understanding of test procedures. After the test is completed, students' answers are coded, categorized based on critical thinking skill indicators, and analyzed quantitatively to determine the distribution of scores, identify dominant aspects, and evaluate indicators that still need improvement.

The data obtained was analyzed using a descriptive statistical method, focusing on the calculation of average scores, standard deviations, and distribution of student scores on each indicator of critical thinking skills. The interpretation of the level of students' critical thinking skills was carried out based on the criteria shown in Table 2.

Table 2. Interpretation of Critical Thinking Skills Score

Score Range	Category
0 – 25	Very Less
26 – 50	Less
51 – 75	Enough
76 – 100	Good

The score categories obtained by students are used to analyze indicators of critical thinking skills that are already strong and aspects that still need attention. The results of this analysis are an important foothold in assessing students' cognitive readiness before they enter laboratory practice. In addition, these findings are also a valuable reference in designing more adaptive and evidence-based laboratory learning strategies. Through this systematic approach, the research not only describes the critical thinking skills profile of prospective chemistry teacher students at the pre-practicum stage, but also opens up opportunities to develop laboratory learning models that are more effective in honing their critical thinking skills.

3. RESULTS AND DISCUSSION

3.1. Results

This section presents the main findings of the study, which include the distribution of critical thinking skill scores, the distribution of students' critical thinking skill categories, and a comparison of the achievements of each indicator.

3.1.1 Descriptive Statistics and Score Distribution

Descriptive statistics are used to determine the average score, standard deviation, and distribution of student scores in the test. Table 3 shows the average critical thinking skill score of students before practicum.

Table 3. Descriptive Statistics Student Critical Thinking Skills Test Scores

N	Mean	SD	Min	Q_1	Q_2	Q_3	Max	Modus
32	60.07	13.15	37.50	50	60	70	85	65

Based on Table 3, it shows that there is a variation in students' critical thinking skills score in the sample group. The average score of 60.07 with a standard deviation of 13.15 indicates a fairly wide spread of scores around the mean. The score range from 37.50 to 85 indicates that there are students with low and high scores, while the quartile distribution (Q1 = 50, Q2 = 60, Q3 = 70) confirms that the majority of students are in the good to good category. In addition, a mode score of 65 that is higher than the median indicates a tendency for more student scores above the middle grade.

3.1.2 Distribution of Critical Thinking Skills Categories

Based on the critical thinking skills score obtained by students, the data is categorized into four levels based on the interpretation of the score that has been determined.

Table 4. Distribution of Student Critical Thinking Skills Category

Score Range	Category	Number of Students	Presentase
0 – 25	Very Less	-	-
26 – 50	Less	7	2.88
51 – 75	Enough	20	62.50
76 – 100	Good	5	15.62

The results in Table 4 show that the majority of students are in the good category, while only a few students are in the good category. These findings indicate that most students do not have optimal critical thinking skills before undertaking the practicum, which can impact their effectiveness in analyzing the results of laboratory experiments.

3.1.3 Comparison of Average Student Scores on Each Critical Thinking Skill Indicator

The identification of the most dominant indicators of critical thinking skills and those that still need to be improved was carried out by analyzing the average student scores on each critical thinking skill indicator. This data is presented in Table 5 and further visualized in Figure 1 to provide a clearer picture of the distribution of student achievement.

Table 5. Average Score on the Critical Thinking Skills Indicator

Indicator	Average Student Score	Category
Focus questions	63.125	Enough
Analyze arguments	48.125	Less
Asking and answering challenging questions	53.125	Enough
Considering the credibility (criteria) of a source	73.437	Enough
Observing and considering observation reports	58.750	Enough
Deducting and considering the results of the deduction	62.500	Enough
Inducing and considering the results of induction	48.738	Less
Create and determine the outcome of the consideration	56.250	Enough
Defining terms and considering a definition	81.250	Good
Identifying assumptions	76.562	Good
Defining an action	51.042	Enough
Interact with others	64	Enough

As a complement, the following Figure 1 presents a comparative visualization of the average student score on each critical thinking skill indicator.

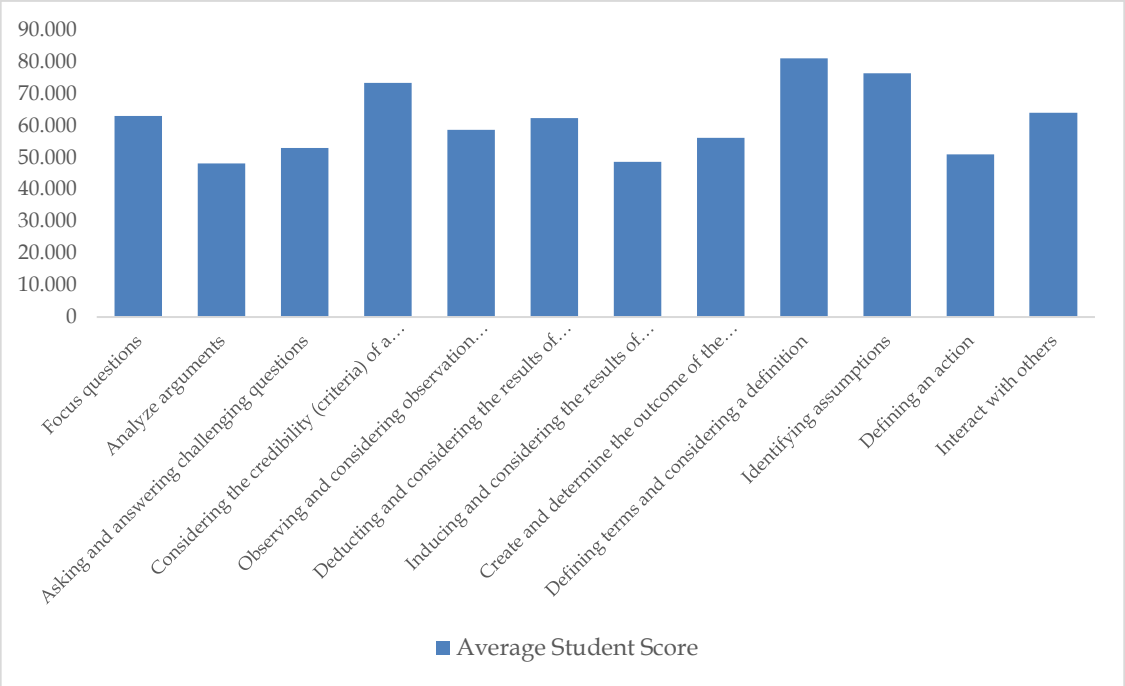

Figure 1. Average Student Score on the Critical Thinking Skills Indicator

Based on Figure 1, it can be seen that the indicator with the highest achievement is defining a term and considering a definition with an average score of 81,250. This shows that students have a good understanding of this aspect, and are able to identify and evaluate definitions critically. In addition, the indicator identifying assumptions also shows high achievements with an average score of 76,562.

In contrast, the indicator with the lowest achievement is analyze arguments with an average score of 48.125. This low score indicates that students still have difficulty in evaluating and constructing arguments logically. The inducing indicators and considering the results of induction also had a relatively low score, which was 48,738, indicating that students still need to improve their skills in drawing conclusions from observed data or patterns.

3.2. Discussion

The results of this study provide an overview of the critical thinking skill profile of students before the implementation of the cation and anion identification practicum. The majority of students were in the good category (62.50%), while only 15.62% reached the good category. These findings show that although most students have a sufficient understanding of basic concepts, there is still a skill gap in high-level critical thinking aspects, especially in the analysis of arguments and the evaluation of scientific information.

In this section, the results of the study are interpreted in more depth by linking the main findings with previous research, analyzing the factors influencing the results, as well as providing recommendations for the development of more effective learning strategies. In addition, this discussion also includes potential future research directions and methods that can be used to overcome the limitations found in this study.

3.2.1 Analysis of Variation in Students' Critical Thinking Skills Score

The high standard deviation (13.15) as well as the score range from 37.50 to 85 indicate that students' critical thinking skills varied significantly in this sample group. A mode score of 65 which is higher than the median (60) indicates that the majority of students have a tendency to be above the middle grade, but still do not reach the optimal level. These results suggest that factors such as students' diverse academic backgrounds will affect the extent to which they are familiar with analytical thinking and problem-solving. The possibility that the learning method applied is still more oriented towards understanding theoretical concepts than critical thinking exercises based on experimental analysis is also one of the factors causing the tendency to occur. In addition, experience in analyzing experimental data also plays a role in determining the extent to which students develop their critical thinking skills before practicum.

Previous research has shown that students who are accustomed to learning based on case analysis and reflective discussion tend to have better critical thinking skills than those who rely solely on memorizing concepts (Aisyah et al., 2024). Laboratory learning that focuses only on experimental procedures without analytical reflection causes students to have difficulty in linking experimental results with valid scientific arguments (Cracolice & Monteyne,

2004). Therefore, this variation in score can be the basis for the development of laboratory learning strategies that are more based on problem solving and reflection on experimental results.

3.2.2 Dominant and Weak Critical Thinking Skills Indicators

The results of the analysis showed that the indicator defining a term and considering a definition obtained the highest score of 81,250 in the good category. These findings indicate that students have a strong ability to understand basic concepts and formulate precise definitions of cation and anion reactions in experiments. The ability to define this concept is crucial, because an accurate understanding of scientific terms allows students to interpret the results of laboratory tests more precisely and in depth.

On the other hand, the indicator analyzing the argument showed the lowest achievement with a score of 48.125 and was in the underserved category. These findings indicate that students still face challenges in critically evaluating scientific information, linking theories to experimental results, and building strong scientific justifications. This difficulty can be caused by several factors, including lack of practice in comparing theories with experimental findings in a systematic manner. In addition, the limitation in the use of analytical questions that require deeper exploration of data is also an obstacle, considering that students are not used to facing questions that encourage critical reasoning. Another contributing factor is the low intensity of reflection on the results of the experiment, so students tend to be less skilled in identifying data discrepancies and asking the follow-up questions needed to enrich their scientific analysis.

Students tend to have difficulty in analyzing scientific arguments if they are not trained to think reflectively during practicum (Parry et al., 2012). Therefore, learning strategies need to place more emphasis on critically evaluating experimental results, with a more evidence-based discussion oriented approach (Anwar et al., 2020; Mandang & Marianus, 2024) as well as exercises in compiling and evaluating scientific arguments (Sastria et al., 2020; Asmaningrum et al., 2018). The application of this strategy is expected to improve students' critical thinking skills and help them develop a deeper understanding of laboratory experiment concepts.

3.2.3 Recommendations for Learning Strategies to Improve Critical Thinking Skills

The findings of this study open up opportunities to apply various approaches aimed at improving students' critical thinking skills in chemistry practicum, especially in cation and anion analysis. One approach that has proven effective is inquiry-based learning. Through this model, students are not only encouraged to explore scientific concepts in more depth, but are also trained to design experiments, analyze data, and build evidence-based arguments through meaningful laboratory experiences (Doucette, 2022), but also encourage the development of students' critical thinking skills through analysis and relate the results of experiments to the theories that have been learned (Ompusunggu et al., 2016; Damayanti et al., 2021). In this model, students are encouraged to formulate their own hypotheses before the practicum begins, which allows them to build an initial understanding of the concepts to be tested (Mandang & Marianus, 2024). During the practicum process, students are guided to evaluate the suitability of experimental data with theory, so that they learn to formulate evidence-based scientific arguments. In addition, the application of post-experimental reflective discussions is necessary so that students can explain the results obtained and answer critical questions (Beck et al., 2014). In this way, students not only follow laboratory procedures, but also develop critical thinking in analyzing the results of experiments.

Strategies to strengthen discussion and scientific justification can also be applied to improve students' critical thinking skills (Zamzam, 2016; Dharmawati et al., 2018; Andi Nurannisa Syam, 2023). Students need to be given more opportunities to analyze and defend their arguments regarding the results of the experiment. One strategy that can be applied is the preparation of reflection-based laboratory reports, where students not only describe the results of the experiment, but also critically evaluate the validity of the data and identify possible sources of errors. In addition, the application of evidence-based group discussions can encourage students to relate the results of experiments to relevant theories, while developing the ability to defend their arguments in structured academic debate forums (Nasir et al., 2024; Ronaldy & Saputra, 2024). Socratic Questioning technique, which is a questioning method that challenges students to think more deeply and helps them to organize and systematically (Rahmawati et al., 2022; Aribah, 2025; Gunawan et al., 2024). This approach is important because it encourages students to not only passively accept information, but also to question, analyze, and construct stronger scientific justifications.

Evidence-based inquiry and discussion models are not the only approaches that can be applied to improve students' critical thinking skills. Other strategies are also effective, such as experimental simulations (Kelleci et al., 2018; Ahmed et al., 2019; Galaresa & Sundari, 2019; Farid, 2023; Sterner et al., 2023) and case studies (Changwong et al., 2018; Susantun, 2023) can also be an effective strategy in improving students' critical thinking skills. To develop the ability to analyze arguments, students need more practice in critically evaluating information. Simulation of experiments with different variables allows students to compare the results and understand the role of each variable in the experiment. The case study analysis of real experiments trained their ability to identify

errors in data design or interpretation. This approach is reinforced through the peer review method, which encourages students to evaluate their classmates' reports, thus enriching a critical understanding of the validity of the arguments and conclusions of the experiment (Walker & Sampson, 2013).

3.2.4 Future Research Implications and Directions

The results of the research have important implications for future research directions in the field of chemistry laboratory learning. One of the aspects that still needs to be explored further is the factors that affect the differences in students' critical thinking skills, such as learning styles, laboratory experience levels, and the effectiveness of the teaching methods applied. Follow-up studies can also test interventions based on specific learning models, such as Project-Based Learning (PBL) or Argument-Driven Inquiry (ADI), to see the extent to which these approaches can improve students' critical thinking skills more significantly. In addition, the use of technology in laboratory learning, such as virtual labs or computer simulation-based experiments, can be an innovation that helps students better understand concepts before they engage in hands-on practicum.

By integrating inquiry-based approaches, scientific discussions, and experimental reflection, students are expected to develop more in-depth critical thinking skills. This will not only increase their effectiveness in analyzing and evaluating the results of experiments, but also equip them with the necessary skills in crafting valid scientific arguments. Therefore, the design of a more adaptive and evidence-based learning strategy is necessary to ensure that students gain a learning experience that not only focuses on the procedural aspects of the practicum, but also on the development of critical thinking skills that are essential in the field of science and chemistry education.

4. CONCLUSION AND RECOMMENDATION

Research shows that the critical thinking skills of prospective chemistry teacher students before practicum still need to be improved. The majority of students were in the fairly good category (62.50%), with indicators defining terms as the highest (81,250, good category) and analyzing arguments as the lowest (48,125, poor category). These results show that students are stronger in understanding concepts but still weak in evaluating scientific information and building evidence-based arguments. These findings emphasize the importance of strengthening critical thinking skills before practicum, especially in the aspects of analysis and evaluation. Inquiry-based learning, reflective discussion, and evaluation of scientific arguments need to be integrated in the preparation of practicum so that students are better prepared to analyze the results of experiments in depth. This research has several limitations. First, this study only measured critical thinking skills before practicum, so it did not provide an idea of how these skills developed after students conducted experiments. Second, this study was conducted on a limited sample (32 students from one study program), so the results could not be generalized to a wider population. Third, this study only uses multiple-choice question instruments, so it has not explored the aspects of critical thinking in depth in the context of open problem-solving or argumentative discussions. Advanced research can explore the development of critical thinking skills during and after practicum, as well as use mixed-methods to gain a deeper understanding. In addition, studies with a wider sample can provide a more comprehensive picture of students' cognitive readiness before laboratory practicum.

REFERENCES

Ahmed, E. S., Hassan, A. M., & Mehany, M. M. (2019). Effect of simulation on critical thinking, satisfaction and self-confidence of nursing students during care of pneumonic child. *International Journal of Advance Research in Nursing*, *2*(1), 131–137. https://doi.org/10.33545/nursing.2019.v2.i1b.41

Aisyah, Mudhar, Hartanti, J., Hasiana, I., & Mufidah, E. F. (2024). Efektivitas Model Pembelajaran Berbasis Project (PBL) untuk Meningkatkan Kemampuan Berpikir Kritis Reflektif. *Jurnal Utile*, *X*(2), 53–62.

Andi Nurannisa Syam. (2023). Pengaruh Model Search, Solve, Create and Share (SSCS) terhadap Kemampuan Berpikir Kritis ditinjau dari Habits of Minds Mahasiswa Tadris Biologi IAIN Kendari. *Jurnal Pendidikan Mipa*, *13*(3), 693–700. https://doi.org/10.37630/jpm.v13i3.1146

Anwar, Y. A. S., Al Idrus, S. W., & Siahaan, J. (2020). Analisis Kesulitan Mahasiswa Calon Guru Dalam Menyusun Laporan Praktikum. *Jurnal Pijar Mipa*, *15*(4), 329–331. https://doi.org/10.29303/jpm.v15i4.1743

Aribah, L. (2025). Analisis Persepsi Mahasiswa terhadap Efektivitas Strategi Pembelajaran Socratic Questioning dalam Meningkatkan Keterampilan Berpikir Kritis. *Dimar Jurnal Pendidikan Islam*, *6*(2), 188–201. https://doi.org/10.58577/dimar.v6i2.339

Asmaningrum, H. P., Koirudin, I., & Kamariah, K. (2018). Pengembangan Panduan Praktikum Kimia Dasar

Terintegrasi Etnokimia Untuk Mahasiswa. *JTK (Jurnal Tadris Kimiya)*, *3*(2), 125–134. https://doi.org/10.15575/jtk.v3i2.3205

Beck, C., Butler, A., & da Silva, K. B. (2014). Promoting inquiry-based teaching in laboratory courses: Are wemeeting the grade? *CBE Life Sciences Education*, *13*(3), 444–452. https://doi.org/10.1187/cbe.13-12-0245

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, *11*(2), 37–48. https://doi.org/10.14254/2071-8330.2018/11-2/3

Cracolice, M. S., & Monteyne, K. (2004). What's Wrong with Cookbooks? A Reply to Ault. *Journal of Chemical Education*, *81*(11), 1559. https://doi.org/10.1021/ed081p1559

Damayanti, E., Suhanda, H., & Suryatna, A. (2021). Analisis Potensi Lks Praktikum Berbasis Inkuiri Terbimbing Pada Topik Identifikasi Protein Dalam Bahan Makanan Untuk Mengembangkan Keterampilan Berpikir Kritis. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *9*(1), 24–36. https://doi.org/10.17509/jrppk.v9i1.52271

Dharmawati, I., Prayogi, S., & Hidayat, S. (2018). Pengaruh Model Pembelajaran Aktif Berbasis Inkuiri (ABI) Terhadap Kemampuan Berpikir Kritis Siswa. *Lensa: Jurnal Kependidikan Fisika*, *6*(1), 8. https://doi.org/10.33394/j-lkf.v6i1.930

Doucette, D. (2022). Measuring the impact of conceptual inquiry-based labs. *Physics Education Research Conference Proceedings*, 151–156. https://doi.org/10.1119/perc.2022.pr.Doucette

Duran, M., & Dökme, I. (2016). The effect of the inquiry-based learning approach on student's critical-thinking skills. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(12), 2887–2908. https://doi.org/10.12973/eurasia.2016.02311a

Ennis, R. H. (2018). Critical Thinking Across the Curriculum: A Vision. *Topoi*, *37*(1), 165–184. https://doi.org/10.1007/s11245-016-9401-4

Farid, I. (2023). Simulation Learning in Economics Education: Empowering Critical Thinking and Rahmatan Lil Alamin Value. *Tadibia Islamika*, *3*(2), 95–102.

Galaresa, A. V., & Sundari, S. (2019). Penggunaan Metode Simulasi Dalam Peningkatan Critical Thinking: Literature Review. *Jurnal Penelitian Keperawatan*, *5*(1). https://doi.org/10.32660/jurnal.v5i1.332

Gunawan, H., Simatupang, E. C. M., & Sari, P. (2024). *Fostering Critical Thinking Skills Through Socratic Questioning : Insights From Widyatama University*. *10*(2), 343–352.

Kelleci, M., Taskin Yilmaz, F., & Aldemir, K. (2018). The Effect of High Fidelity Simulation Training on Critical Thinking and Problem Solving Skills in Nursing Students in Turkey. In *Educational Research in Medical Sciences* (Vol. 7, Issue 2). https://doi.org/10.5812/erms.83966

Maaranen, K., & Stenberg, K. (2017). Portraying reflection: the contents of student teachers' reflection on personal practical theories and practicum experience*. *Reflective Practice*, *18*(5), 699–712. https://doi.org/10.1080/14623943.2017.1323729

Mandang, T., & Marianus, M. (2024). Pengembangan Panduan Praktikum Elektronika Dasar Alat Electricity Demonstration Kit-B Berbasis Model Inkuiri Terbimbing. *Jurnal Penelitian Sains Dan Pendidikan (JPSP)*, *4*(1), 43–56. https://doi.org/10.23971/jpsp.v4i1.7903

Maros, M., Korenkova, M., Fila, M., Levicky, M., & Schoberova, M. (2023). Project-based learning and its effectiveness: evidence from Slovakia. *Interactive Learning Environments*, *31*(7), 4147–4155. https://doi.org/10.1080/10494820.2021.1954036

Nasir, M., Fendi, H., & Indriyani, V. (2024). Metode Debat dalam Pembelajaran: Sebuah Upaya Peningkatan Kemampuan Berpikir Kritis Mahasiswa. *Jurnal Bahasa Dan Sastra*, *12*(1), 126. https://doi.org/10.24036/jbs.v12i1.128155

Oktariani, O., Febliza, A., & Fauziah, N. (2020). Keterampilan Berpikir Kritis Calon Guru Kimia sebagai Kesiapan Menghadapi Revolusi Industri 4.0. *Journal of Natural Science and Integration*, *3*(2), 114. https://doi.org/10.24014/jnsi.v3i2.8791

Ompusunggu, T., Turnip, B. M., & Sirait, M. (2016). Efek Inquiry Training Dan Berpikir Kritis Terhadap Keterampilan Proses Sains Fisika. *Jurnal Pendidikan Fisika*, *5*(2), 96–100.

http://jurnal.unimed.ac.id/2012/index.php/jpf

Parry, D., Walsh, C., Larsen, C., & Hogan, J. (2012). Reflective practice: A place in enhancing learning in the undergraduate bioscience teaching laboratory? *Bioscience Education*, *19*(1), 1–10. https://doi.org/10.11120/beej.2012.19000004

Rahmawati, D., Vahlia, I., Mustika, M., Yunarti, T., & Nurhanurawati, N. (2022). Socrates questions to optimize students critical thinking. *Al-Jabar : Jurnal Pendidikan Matematika*, *13*(2), 372–382. https://doi.org/10.24042/ajpm.v13i2.13728

Ramalis, T. R., & Rusdiana, D. (2015). Karakteristik Pengembangan Tes Keterampilan Berpikir Kritis Bumi dan Antariksa Untuk Calon Guru. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *01*(2), 51–58. https://doi.org/10.21009/1.01209

Ronaldy, M., & Saputra, A. (2024). *Pengaruh Metode Socrates Terhadap Kemampuan Berpikir Historis : Analisis Pada Pembelajaran Sejarah Berbasis Masalah The Effect of The Socratic Method on Historical Thinking Ability : Analysis of Problem-Based History Learning*. *18*(2), 196–208.

Sastria, E., Novinovrita M, N. M., & Haryanto, T. (2020). Pengembangan Penuntun Praktikum Biologi Umum Berbasis Problem Solving dengan Menggunakan 3D Pageflip untuk Menumbuhkan Keterampilan Kerja Ilmiah Mahasiswa Biologi. *Tarbawi : Jurnal Ilmu Pendidikan*, *16*(1), 95–103. https://doi.org/10.32939/tarbawi.v16i01.574

Sterner, A., Sköld, R., & Andersson, H. (2023). Effects of Blended Simulation on Nursing Students' Critical Thinking Skills: A Quantitative Study. *SAGE Open Nursing*, *9*. https://doi.org/10.1177/23779608231177566

Susantun. (2023). Pengembangan Kreativitas dan Kemampuan Berpikir Kritis pada Mata Pelajaran PPKn di Sekolah Menengah Pertama. *De Cive: Jurnal Penelitian Pendidikan Pancasila Dan Kewarganegaraan*, *3*(2), 39–44.

Walker, J. P., & Sampson, V. (2013). Argument-driven inquiry: Using the laboratory to improve undergraduates' science writing skills through meaningful science writing, peer-review, and revision. *Journal of Chemical Education*, *90*(10), 1269–1274. https://doi.org/10.1021/ed300656p

Yulianti, L., Ramalis, T. R., & Purwanto, P. (2020). Karakteristik Tes Keterampilan Berpikir Kritis Pada Materi Hukum Newton Berdasarkan Teori Respon Butir. *WaPFi (Wahana Pendidikan Fisika)*, *5*(1), 66–70. https://doi.org/10.17509/wapfi.v5i1.22885

Zamzam, K. F. (2016). Pendekatan Problem Based Learning untuk Mengembangkan Kemampuan Berpikir Kritis Mahasiswa. *Pedagogia : Jurnal Pendidikan*, *5*(2), 279–286. https://doi.org/10.21070/pedagogia.v5i2.261