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Preliminary Study on Students Critical Thinking Skills on Temperature and Heat Material

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Abstract: This preliminary study investigates the critical thinking skills of Grade VII students at SMP Negeri 01 Belitang Jaya on the topic of temperature and heat, focusing on Ennis's critical thinking indicators. It aims to identify students' critical thinking levels based on five indicators and highlight areas needing improvement. The study uses a qualitative descriptive method, involving 154 students from five classes. Data were collected through questionnaires covering five indicators: providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and managing strategies and tactics. The findings show that students excel in providing simple explanations (74.66%, high category). However, they perform moderately in building basic skills (46.79%), drawing conclusions (58.54%), and providing further explanations (41.60%). Managing strategies and tactics scored the lowest (31.20%, low category). These results suggest a need for targeted educational interventions, especially in strategy and tactics management. The study provides a reference for developing interactive teaching materials, such as augmented reality-assisted e-modules, to improve students' engagement and critical thinking skills. It lays the groundwork for innovative teaching strategies to make the learning process more effective and engaging.

Keywords: Critical thinking skills; Temperature and heat; Augmented reality; E-module

Introduction

Critical thinking skills are essential in education, particularly in science subjects like physics, where students are required to understand concepts, analyze problems, and apply knowledge to real-world situations (Yenita et al., 2022). The development of these skills is essential for equipping students to meet the challenges of the 21st century, including logical reasoning, scientific thinking, and solving complex problems (Fitri & Asrizal, 2023). However, various studies indicate that many students struggle with critical thinking, especially on topics like temperature and heat in physics, and based on observations at SMP Negeri 01 Belitang Jaya, the critical thinking abilities of VII grade students, especially in science, remain inadequately developed (Januarti et al., 2023).

This preliminary study aims to explore the current level of critical thinking skills among Grade VII students at SMP Negeri 01 Belitang Jaya, specifically focusing on their understanding of temperature and heat material. The study is intended to gather baseline data on students' abilities to provide simple explanations, build foundational skills, draw conclusions, and strategize and tactically navigate this material (Islamiati et al., 2024).

There is an increasing demand to enhance critical thinking skills in schools, particularly in science education, as these skills are considered a vital component of 21st-century competence (Nadia et al., 2024). Topics like temperature and heat are often perceived as abstract by students, leading to difficulties in grasping the underlying scientific principles (Fathurohman et al., 2023). Previous research has shown that traditional teaching methods are insufficient to foster deep understanding and critical thinking in this area (Hikmah et al., 2023). Therefore, it is necessary to explore how well students perform in these aspects and

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identify teaching gaps (Chairatunnisa et al., 2023). The rationale for conducting this preliminary study at SMP Negeri 01 Belitang Jaya is to determine the current state of students' critical thinking skills before implementing any educational interventions, such as the development of augmented reality-assisted electronic modules (Nisah et al., 2024). Understanding students' baseline abilities will allow educators to design targeted strategies that address specific weaknesses and enhance the overall learning experience (Mulia et al., 2024).

The novelty of this study lies in its specific focus on Grade VII students' critical thinking skills in the context of temperature and heat material (Patandung, 2023). Although many studies have explored critical thinking in general, few have focused on this specific topic within physics education (Priyadi et al., 2018).

The novelty in the needs analysis for critical thinking skills lies in its multidimensional approach, integrating cognitive, affective, and contextual aspects to provide a holistic understanding of students' needs (Fitra, 2022; Moto, 2019). Additionally, the use of technology, such as augmented reality (AR), in data collection creates interactive and authentic learning experiences relevant to contemporary developments (Maulana et al., 2019). This analysis is also based on the demands of the Merdeka Curriculum, particularly in relation to the elements of the Pancasila Student Profile, ensuring its alignment with national educational needs (Laar et al., 2019). The approach combines qualitative and quantitative methods through interviews, observations, and critical thinking skills tests, yielding rich and triangulated data (Marisda et al., 2024). Moreover, the focus on the relationship between critical thinking skills and conceptual understanding of subjects like temperature and heat offers deeper insights into how these aspects impact students' learning processes (Suhada, 2017). Furthermore, the analysis considers contextual relevance to global issues, such as climate change, ensuring that the developed critical thinking skills have direct implications for real-world problem-solving (Istiyono et al., 2019; Jamaludin et al., 2022). This approach makes the needs analysis more innovative, relevant, and impactful for learning development (Istiyono et al., 2019).

Furthermore, this study will lay the groundwork for creating innovative learning resources, such as augmented reality-assisted e-modules, which have yet to be widely implemented in junior high school physics education in Indonesia (Istiyono et al., 2019; Kurnianto et al., 2024). The integration of technology in education offers a new approach to enhance student engagement and improve their ability to think critically about complex scientific concepts (Aslan & Aybek, 2024). By addressing the current gaps in pedagogical strategies and technology integration, this research will contribute to advancements in educational practice and provide valuable insights into how critical thinking can be more effectively developed in the classroom (Nadia et al., 2024). Based on the above description, the author intends to analyze the critical thinking skills related to temperature and heat material in Grade VII students at SMP Negeri 01 Belitang Jaya.

Method

This research uses a qualitative descriptive approach to assess the critical thinking skills of Grade VII students on the topic of temperature and heat (Marlina et al., 2022). The design aims to provide a general overview of students' critical thinking skills through the collection and analysis of relevant data. The participants in this study are all VII grade students at SMP Negeri 01 Belitang Jaya. The following needs analysis research flow can be seen in Figure 1.

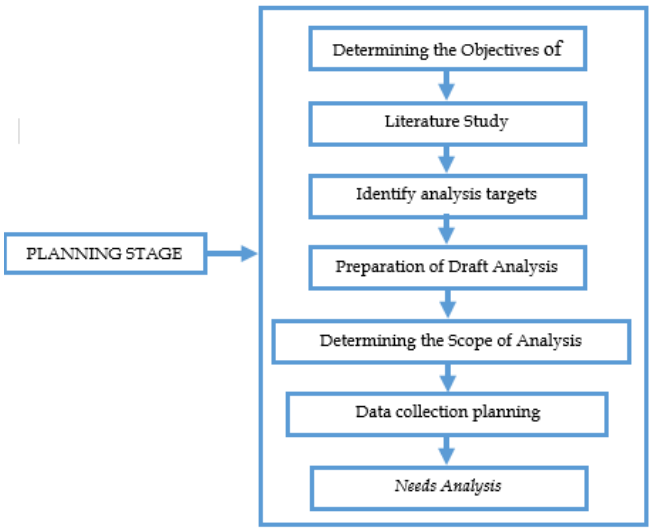

Figure 1. Flow of requirements analysis data collection

The research tool employed is a Critical Thinking Skills questionnaire, which is specifically designed to assess different aspects of students' critical thinking abilities (Rianti et al., 2020). To obtain an initial overview of students' level of thinking skills, a questionnaire representing 5 indicators of critical thinking skills was administered (Ennis, 2018). The instrument consisted of 10 questions given to the research subjects, namely 5 classes with 154 students who were available and willing to participate in the analysis and had implemented the Merdeka curriculum at SMP Negeri 01 Belitang Jaya. Data analysis involved calculating the percentage of students' skill levels at SMP Negeri 01 Belitang Jaya regarding the material on temperature and heat. The results of the students' answer scores were

differentiated by each indicator and each class for analysis and comparison (Prameswari et al., 2018). If expressed mathematically, it is as follows:

$$NP = \frac{R}{SM} \times 100\% \quad (1)$$

Description:
NP : Percentage value sought or expected
R : Total score of critical thinking skills indicators
SR : Maximum score of essential skills of thinking indicators

The level of critical thinking skills is divided into three categories: low, medium, and high (Marlina et al., 2018).

Tabel 1. Levels of critical thinking skills

Category	Percentage Score (%)
Low	$33 < 0$
Medium	$34 - 67$
High	$68 > 100$

Result and Discussion

The findings of this initial study are presented as a qualitative description, with the goal of depicting the critical thinking skills of VII grade students at SMP Negeri 01 Belitang Jaya regarding the topic of temperature and heat. These results are derived from data analysis conducted using questionnaires (Atkins et al., 2022), It is clear that students demonstrate different levels of critical thinking skills (Rositawati, 2019). This research follows the critical thinking skill indicators outlined by Ennis, as shown in Table 2.

Table 2. Critical thinking indicators (Ennis, 1996)

Indicator	Sub-Indicator
Provide simple explanation	Focus on the question, Analyze the question, Ask and answer questions
Build basic skills	Consider whether the source is trustworthy or not, Observe and consider the observation report
Summarize	Conduct and consider the results of education, Conduct and consider the results of induction, Make and determine value judgments
Provide further explanation	Define, consider a definition, Identify assumptions
Manage strategy and tactics	Determine an action, Interact with others

After conducting a preliminary study in five classes of Grade VII students at SMP Negeri 01 Belitang Jaya, the average critical thinking skills of the students were analyzed based on five indicators according to (Ennis, 2018). The results of this analysis are presented in the form of a bar chart, which includes the following indicators.

First Class Preliminary Study

The following chart illustrates the analysis results of critical thinking skills among Grade VII-1 students based on five key indicators: Provide Simple Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics (Elisanti et al., 2018). The chart presents data in two categories: the number of students who met the indicators (Yes) and those who did not meet the indicators (No). This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

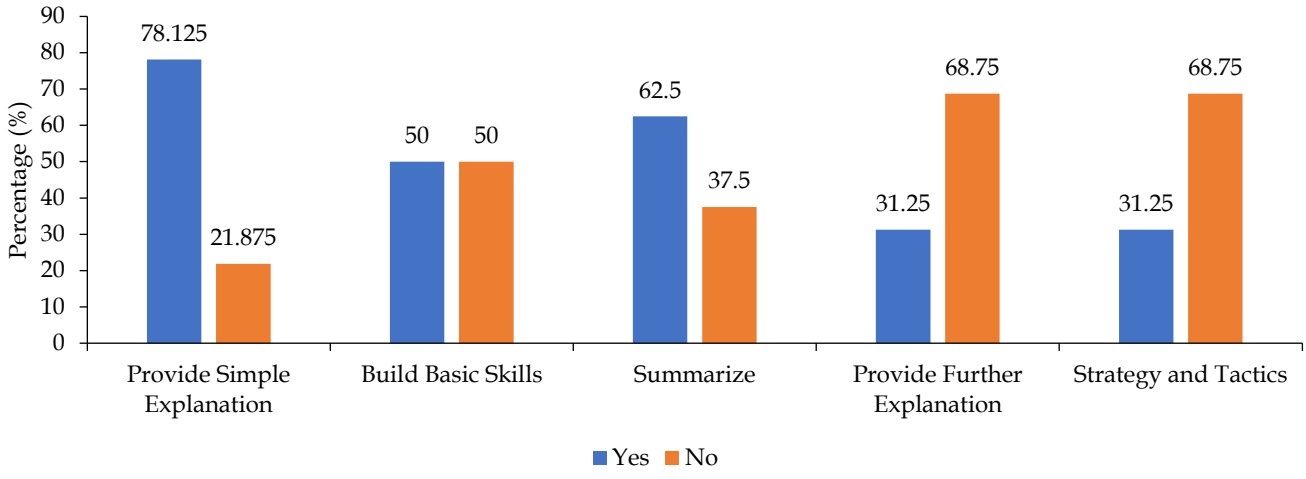

Figure 2. Results of preliminary study in class VII 1

Based on the bar chart above, which shows the results of the analysis of critical thinking skills of Grade VII-1 students at SMP Negeri 01 Belitang Jaya, the data is presented in five critical thinking skill indicators

according to Ennis (1996). The chart compares two categories, "Yes" and "No," which represent the success or failure of students in achieving the critical thinking skill indicators.

For the Provide Simple Explanation indicator, 78.125% of students were able to provide a simple explanation, while 21.875% were unable to meet this indicator. For the Build Basic Skills indicator, the results show that half of the students 50% demonstrated the ability to build basic skills, while the other half 50% did not succeed. Furthermore, for the Summarize indicator, 62.5% of students were able to summarize information, while 37.5% of students were unable to do so. For the Provide Further Explanation indicator, only 31.25% of students were able to give a more in-depth explanation, while the majority, 68.75%, did not meet this indicator. Finally, for the Strategy and Tactics indicator, the results were similar to the previous indicator, with only 31.25% of students demonstrating skills in strategy and tactics, while 68.75% of students did not show ability in this aspect.

Overall, these results indicate that the majority of students have good skills in providing simple explanations and summarizing information. However, there are weaknesses in the indicators for providing further explanations and managing strategy and tactics. This data suggests that further intervention is needed to strengthen students' critical thinking skills in more complex aspects.

Second Class Preliminary Study

The following chart illustrates the analysis results of critical thinking skills among Grade VII-2 students based on five key indicators: Provide Simple Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics. The chart presents data in two categories: the number of students who met the indicators (Yes) and those who did not meet the indicators (No). This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

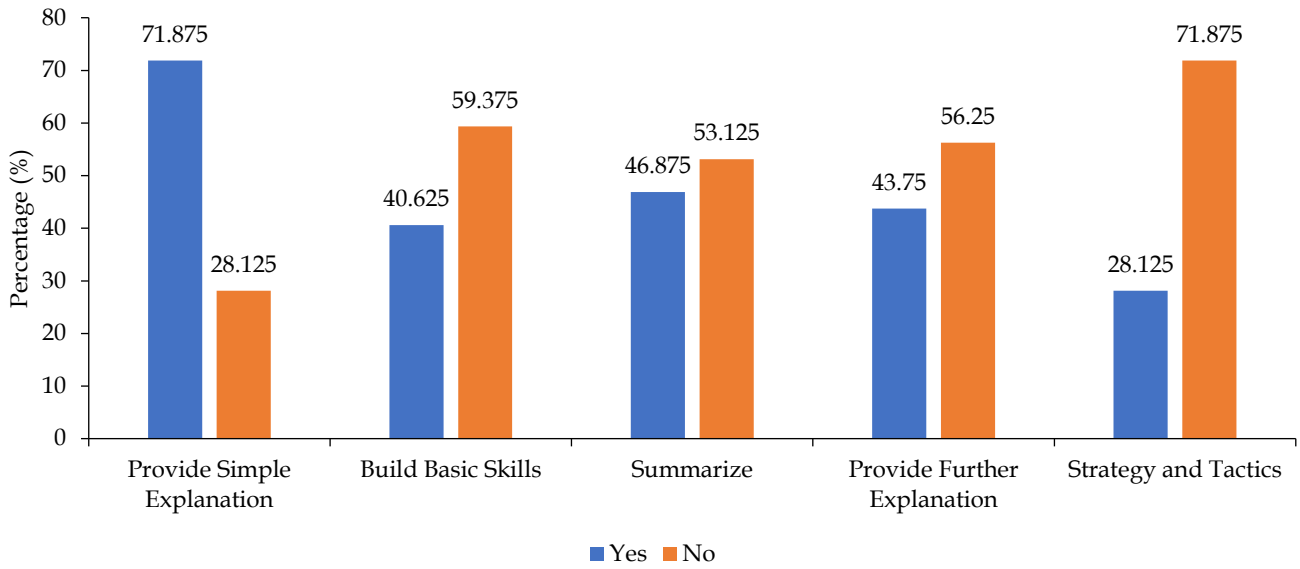

Figure 3. Results of preliminary study in class VII 2

Based on the bar chart above, which shows the results of the critical thinking skills analysis of Grade VII-2 students at SMP Negeri 01 Belitang Jaya, there are noticeable differences in achievement across each critical thinking skill indicator. In the Provide Simple Explanation indicator, 71.875% of students were able to provide simple explanations, while the remaining 28.125% were not able to meet this indicator. For the Build Basic Skills indicator, only 40.625% of students succeeded, whereas the majority, 59.375%, faced difficulties. Next, in the Summarize indicator, 46.875% of students were able to summarize information, while 53.125% did not succeed, indicating that students' ability to summarize was fairly balanced. For the Provide Further Explanation indicator, only 43.75% of students were able to give in-depth explanations, while the remaining 56.25% could not meet this criterion. Lastly, the Strategy and Tactics indicator showed the greatest weakness, with only 28.125% of students able to manage strategies, while the other 71.875% did not succeed.

Third Class Preliminary Study

The following chart illustrates the analysis results of critical thinking skills among Grade VII-3 students based on five key indicators: Provide Simple

Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics. The chart presents data in two categories: the number of students who met the indicators (Yes) and those who did not meet the indicators (No). This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

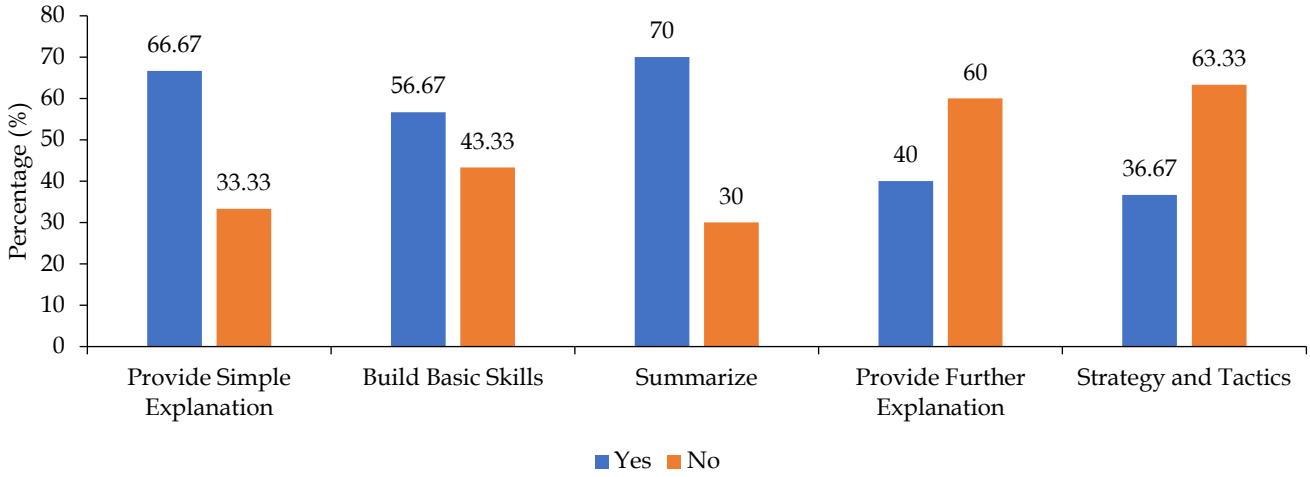

Figure 4. Results of preliminary study in class VII 3

Based on the bar chart above, the analysis of critical thinking skills of the VII-3 grade students at SMP Negeri 01 Belitang Jaya shows varying achievements across each indicator. For the Providing Simple Explanations indicator, 66.67% of the students were able to provide simple explanations, while 33.33% were not yet able to meet this indicator. The Building Basic Skills indicator reveals that 56.67% of the students succeeded, while 43.33% still faced difficulties. For the Summarizing indicator, the majority of students, 70%, were able to summarize information well, while 30% were not yet successful. Furthermore, on the Providing Advanced Explanations indicator, only 40% of the students were able to provide in-depth explanations, while the remaining 60% had not met the criteria. The final indicator, Strategizing and Tactics, revealed the greatest weakness, with only 36.67% of students succeeding, while 63.33% were not yet able to effectively organize strategies. Overall, the "Summarizing" indicator showed the highest achievement, while the greatest weakness was observed in the "Strategizing and Tactics" indicator.

Fourth Class Preliminary Study

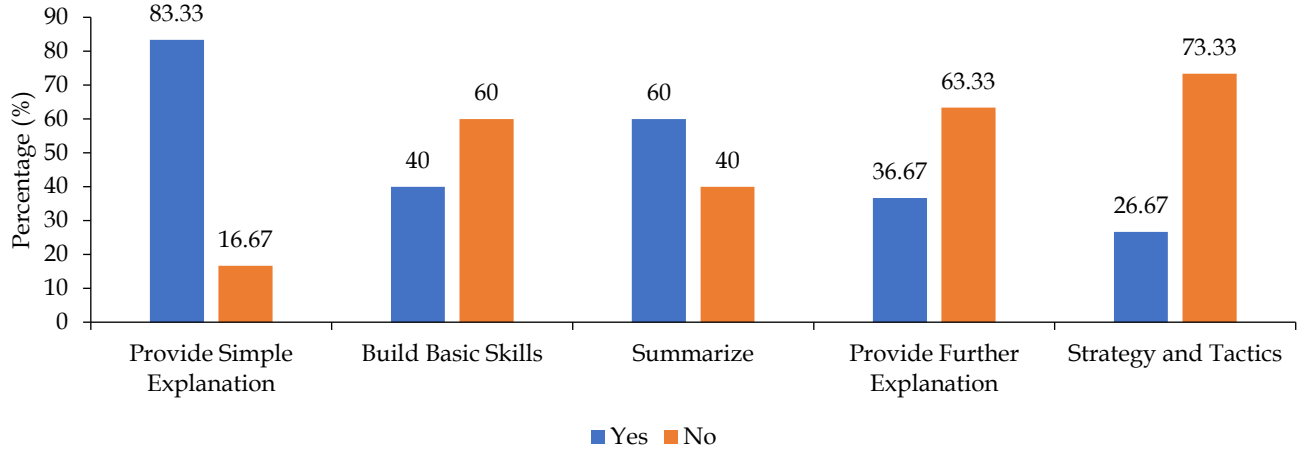

Figure 5. Results of preliminary study in class VII 4

The chart in Figure 5 illustrates the analysis results of critical thinking skills among Grade VII-4 students based on five key indicators: Provide Simple Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics. The chart presents data in two categories: the number of students

who met the indicators (Yes) and those who did not meet the indicators (No). This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

Based on the bar chart in Figure 5, the analysis of critical thinking skills of the VII-4 grade students at SMP Negeri 01 Belitang Jaya shows different achievements across each indicator. For the Providing Simple Explanations indicator, 83.33% of the students were able to provide simple explanations, while 16.67% had not yet met this indicator. For the Building Basic Skills indicator, only 40% of the students succeeded, while 60% had difficulties in building basic skills. Furthermore, on the Summarizing indicator, 60% of the students were able to summarize information well, but 40% had not yet succeeded. The Providing Advanced Explanations indicator showed that only 36.67% of the students were able to provide in-depth explanations, while 63.33% had not yet met the criteria. The final indicator, Strategizing and Tactics, represented the greatest weakness, with only 26.67% of students succeeding, while 73.33% were not yet able to organize strategies effectively. Overall, the Providing Simple Explanations indicator showed the highest achievement, while the Strategizing and Tactics indicator revealed the most significant weakness.

Fifth Class Preliminary Study

The following chart illustrates the analysis results of critical thinking skills among Grade VII-2 students based on five key indicators: Provide Simple Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics. The chart presents data in two categories: the number of students who met the indicators (Yes) and those who did not meet the indicators (No). This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

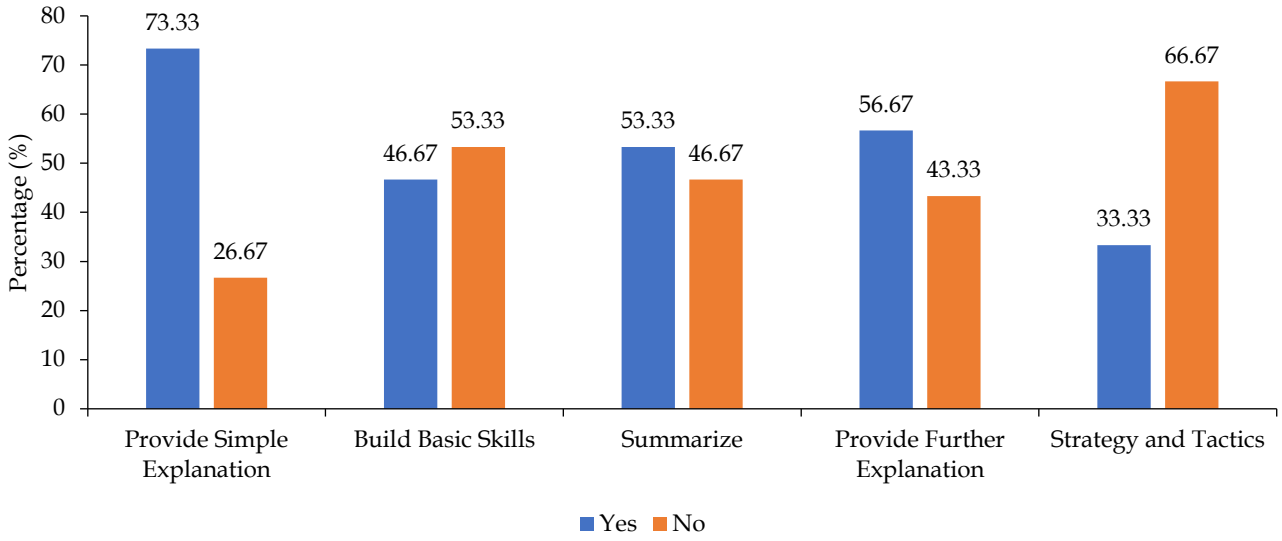

Figure 6. Results of preliminary study in class VII 5

Based on the bar chart above, the analysis of critical thinking skills of the VII-5 grade students at SMP Negeri 01 Belitang Jaya shows varying achievements across each indicator. For the Providing Simple Explanations indicator, 73.33% of the students were able to provide simple explanations well, while 26.67% had not yet succeeded. The Building Basic Skills indicator reveals that 46.67% of the students succeeded, while 53.33% had difficulties in meeting this indicator. Furthermore, on the Summarizing indicator, 53.33% of the students were able to summarize information well, while 46.67% had not yet succeeded. The Providing Advanced Explanations indicator shows that 56.67% of the students were able to provide more in-depth explanations, but 43.33% still struggled. For the Strategizing and Tactics indicator, 33.33% of the students succeeded, while the majority, 66.67%, were not yet able to organize strategies effectively. Overall, the Providing Simple Explanations indicator showed the highest achievement, while Strategizing and Tactics was the greatest weakness among the VII-5 students.

Average of All Indicators

The following chart illustrates the analysis results of critical thinking skills among Grade VII 1-5 students based on five key indicators: Provide Simple Explanation, Build Basic Skills, Summarize, Provide Further Explanation, and Strategy and Tactics. This analysis aims to provide a detailed overview of students' achievements in each critical thinking skill indicator.

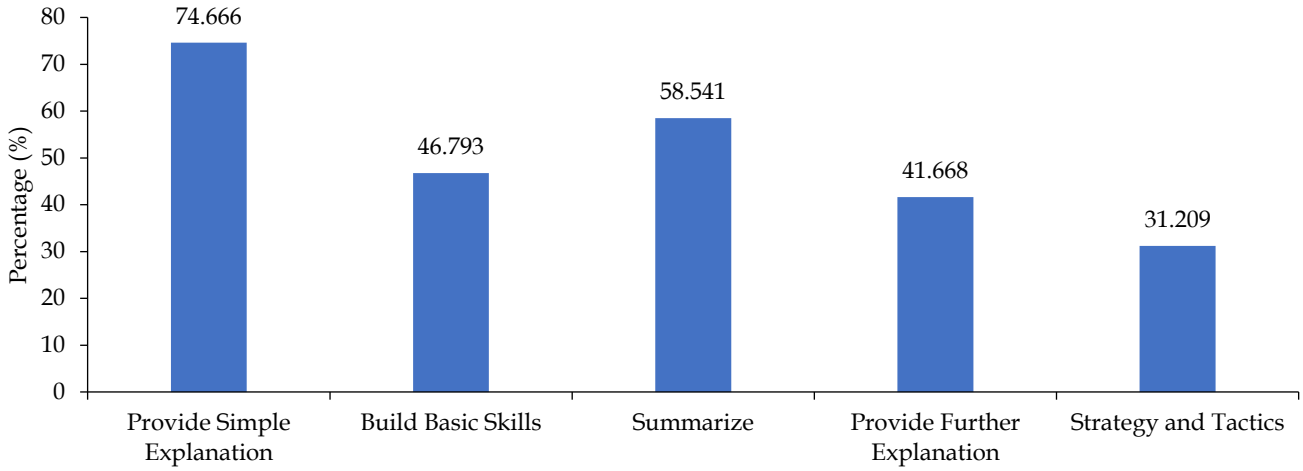

Figure 7. Average of all indicators in class VII 1-5

Figure 7 shows the overall average results of the 5 indicators of critical thinking skills (Ennis, 1996) for 5 classes at SMP Negeri 01 Belitang Jaya which can be seen in Table 3.

Table 3. Level of critical thinking skills for each indicator at SMP Negeri 01 Belitang Jaya

Indicator	Average (%)	Category
Provide simple explanation	74.66	High
Build basic skills	46.79	Medium
Summarize	58.54	Medium
Provide further explanation	41.68	Medium
Manage strategy and tactics	31.20	Low

Based on the bar chart showing the average of all critical thinking skill indicators for 7th-grade students in classes 1-5, it can be seen that there is variation in achievement across each indicator. The Provide Simple Explanation indicator obtained the highest average score, at 74.666%, which falls into the High category. This indicates that the majority of students are able to provide simple explanations well. The Summarizing indicator is in second place with a score of 58.541%, which falls into the Moderate category, suggesting that students' ability to summarize is fairly good, although there is room for improvement. The Building Basic Skills indicator recorded a score of 46.793%, also in the Moderate category, indicating that students' ability to build basic skills is still at a moderate level and needs strengthening. On the Providing Further Explanation indicator, students scored 41.668%, which also falls into the Moderate category, showing that they still face challenges in giving more in-depth explanations. The lowest-scoring indicator is Strategy and Tactics, with a score of 31.209%, which falls into the Low category, indicating that many students struggle to develop strategies and tactics in critical thinking. Overall, students show good ability in providing simple explanations but require further intervention to enhance their critical thinking skills, especially in the areas of strategy and in-depth explanation (Rasyid et al., 2018).

The differences in the level of critical thinking skills indicators within the same school can be influenced by several factors. First, the teaching methods used by teachers may vary from class to class, affecting student outcomes (Sugianto et al., 2017). Second, the quality of teaching materials may not be consistent, which impacts learning results. Third, the learning environment in different classrooms, such as the atmosphere and facilities, can influence critical thinking skills (Ashari et al., 2024). Additionally, students' basic abilities vary, as each student has a different knowledge background. Students' motivation and interest in the subject matter also vary, which can affect learning outcomes (Husein et al., 2017). Parental and family support plays an important role in the development of students' skills. Lastly, previous learning experiences influence how prepared students are to handle tasks that require critical thinking skills (Helen et al., 2023).

Conclusion

The findings of this study suggest that the critical thinking skills of grade VII students at SMP Negeri 01 Belitang Jaya, especially related to the topics of temperature and heat, continue to differ. The strongest indicator of critical thinking skills is the capacity to give straightforward explanations, whereas more advanced components, such as strategies and tactics, exhibit lower results. Factors such as teaching methods, the quality of teaching materials, the learning environment, students' basic abilities, motivation, family support, and previous learning experiences play a significant role in influencing students' critical thinking skill levels. The findings of this study highlight the need for more

targeted educational interventions to enhance students' critical thinking abilities, especially in terms of strategies and deeper explanations. To improve students' critical thinking skills in understanding temperature and heat material, it is essential to experiment with interactive learning materials, one of which is the development of an Android-based e-module with augmented reality technology. This can be implemented to allow students to directly interact with scientific concepts through engaging 3D visualizations and provide exercises that encourage analysis and evaluation of real-life situations.

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Author Contributions
Conceptualization, I.N.R. and L.M.; methodology, formal analysis, investigation, writing original draft preparation, visualization, I.N.R.; software, resources, project administration, I.; validation, I.N.R., L.M., and I.; data curation, supervision, L.M.; writing review and editing, L.M.; funding acquisition, I. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
All author declared that there is no conflict of interest.

References

Ashari, H., Makmur, E., Sari, D. A. L., Muchtar, A., & Burhan, M. I. (2024). Pelatihan Augmented Reality (AR) untuk Meningkatkan Kompetensi Guru di Era Digital. *TEKNOVOKASI: Jurnal Pengabdian Masyarakat*, 15–21. https://doi.org/10.59562/teknovokasi.v2i1.1300

Aslan, S., & Aybek, B. (2024). Development of Critical-Thinking Skills Rubric within the Scope of Multicultural Education. *Educational Process International Journal*, *13*(3). https://doi.org/10.22521/edupij.2024.133.8

Atkins, P., Paula, J. D., & Keeler, J. (2022). *Atkins' Physical Chemistry* (12th ed.). Oxford University Press. https://doi.org/10.1093/hesc/9780198847816.001.0001

Chairatunnisa, A., Marlina, L., & Wiyono, K. (2023). Improvement of Critical Thinking Skills of Junior High School Students on Heat Transfer Material. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10377–10386. https://doi.org/10.29303/jppipa.v9i11.5681

Elisanti, E., Sajidan, S., & Prayitno, B. A. (2018). The Profile of Critical Thinking Skill Students in XI Grade of Senior High School. *Proceedings of the 1st Annual International Conference on Mathematics, Science, and Education (ICoMSE 2017)*. Malang, Indonesia. https://doi.org/10.2991/icomse-17.2018.36

Ennis, R. H. (1996). Critical Thinking Dispositions: Their Nature and Assessability. *Informal Logic*, *18*(2). https://doi.org/10.22329/il.v18i2.2378

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

Fathurohman, A., Oklilas, A. F., Marlina, L., Kurdiati, L. A., Susiloningsih, E., Azhar, A., & Samsuryadi, S. (2023). Effectiveness of Using the Mobile Learning App for STEM-Based High School Physics Materials as Indonesian Student Learning Resources on Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1018–1023. https://doi.org/10.29303/jppipa.v9i3.2991

Fitra, D. K. (2022). Analisis Penerapan Pembelajaran Berdiferensiasi dalam Kurikulum Merdeka pada Materi Tata Surya di Kelas VII SMP. *Tunjuk Ajar: Jurnal Penelitian Ilmu Pendidikan*, *5*(2), 278. https://doi.org/10.31258/jta.v5i2.278-290

Fitri, A. D., & Asrizal, A. (2023). Development of Physics E-Module Integrated with PBL Model and Ethnoscience to Improve Students' 21st Century Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 10610–10618. https://doi.org/10.29303/jppipa.v9i12.5877

Helen, H., Marlina, L., & Fathurohman, A. (2023). Penggunaan Media Flashcard Berbasis Augmented Reality untuk Meningkatkan Hasil Belajar Peserta Didik. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *6*(10), 7699–7702. https://doi.org/10.54371/jiip.v6i10.2896

Hikmah, N., Febriya, D., Asrizal, A., & Mufit, F. (2023). Impact of the Project-Based Learning Model on Students' Critical and Creative Thinking Skills in Science and Physics Learning: A Meta-Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 892–902. https://doi.org/10.29303/jppipa.v9i10.4384

Husein, S., Herayanti, L., & Gunawan, G. (2017). Pengaruh Penggunaan Multimedia Interaktif Terhadap Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa pada Materi Suhu dan Kalor. *Jurnal Pendidikan Fisika dan Teknologi*, *1*(3), 221–225. https://doi.org/10.29303/jpft.v1i3.262

Islamiati, E. F., Subagia, I. W., & Suma, K. (2024). Development of Teaching Modules in the Implementation of the Independent Curriculum to Improve the Quality of the Learning Process and Student Learning Outcomes. *Jurnal Penelitian*

Pendidikan IPA, *10*(11), 9097–9105. https://doi.org/10.29303/jppipa.v10i11.7521

Istiyono, E., Dwandaru, W. S. B., Lede, Y. A., Rahayu, F., & Nadapdap, A. (2019). Developing IRT-Based Physics Critical Thinking Skill Test: A CAT to Answer 21st Century Challenge. *International Journal of Instruction*, *12*(4), 267–280. https://doi.org/10.29333/iji.2019.12417a

Jamaludin, J., Kakaly, S., & Batlolona, J. R. (2022). Critical Thinking Skills and Concepts Mastery on the Topic of Temperature and Heat. *Journal of Education and Learning (EduLearn)*, *16*(1), 51–57. https://doi.org/10.11591/edulearn.v16i1.20344

Januarti, J., Islami, N., & Yennita, Y. (2023). Development of Physics Modules Based on the REACT Learning Model of Sound Wave Material to Improve the Ability to Understand Concepts. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8489–8497. https://doi.org/10.29303/jppipa.v9i10.4393

Kurnianto, F., Rahmat, A. D., & Kuswanto, H. (2024). The Effect of Augmented Reality Integrated Traditional Games Nglarak Blarak to Improve Critical Thinking and Graphical Representation Skills. *Pegem Journal of Education and Instruction*, *14*(2). https://doi.org/10.47750/pegegog.14.02.41

Laar, E. V., Deursen, A. J. A. M. V., Dijk, J. A. G. M. V., & Haan, J. D. (2019). Determinants of 21st-Century Digital Skills: A Large-Scale Survey Among Working Professionals. *Computers in Human Behavior*, *100*, 93–104. https://doi.org/10.1016/j.chb.2019.06.017

Marisda, D. H., Nurlina, N., Maruf, M., Rahmawati, R., Idamayanti, R., & Akbar, M. (2024). Challenges in Secondary School Education: Profile of Physics Students' Critical Thinking Skills. *Journal of Education and Learning (EduLearn)*, *18*(3), 1091–1098. https://doi.org/10.11591/edulearn.v18i3.21666

Marlina, L., Liliasari, L., Tjasyono, B., & Hendayana, S. (2018). Improving the Critical Thinking Skills of Junior High School Students on Earth and Space Science (ESS) Materials. *Journal of Physics: Conference Series*, *1013*, 012063. https://doi.org/10.1088/1742-6596/1013/1/012063

Marlina, L., Paramitha, G. P., & Sriyanti, I. (2022). Development of Electronic Modules Based on Critical Thinking Skills on Vibration, Waves, and Sound Materials for Junior High School Students. *Jurnal Pendidikan Sains Indonesia*, *10*(2), 342–354. https://doi.org/10.24815/jpsi.v10i2.23844

Maulana, I., Suryani, N., & Asrowi, A. (2019). Augmented Reality: Solusi Pembelajaran IPA di Era Revolusi Industri 4.0. *Proceedings of The ICECRS*, *2*(1), 19–26. https://doi.org/10.21070/picecrs.v2i1.2399

Moto, M. M. (2019). Pengaruh Penggunaan Media Pembelajaran dalam Dunia Pendidikan. *Indonesian Journal of Primary Education*, *3*(1), 20–28. https://doi.org/10.17509/ijpe.v3i1.16060

Mulia, N., Advinda, L., Syamsurizal, S., & Ahda, Y. (2024). Pengembangan E-Modul Berbasis Android Berbentuk Flipbook pada Materi Sistem Ekskresi dan Sistem Koordinasi untuk Peserta Didik Kelas XI SMA. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2388–2397. https://doi.org/10.29303/jppipa.v10i5.7237

Nadia, H., Wiyono, K., & Sriyanti, I. (2024). Effectiveness of Using Physics E-Modules Based on Local Wisdom of Palembang City Food to Improve Collaboration Skills for High School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6376–6383. https://doi.org/10.29303/jppipa.v10i9.8439

Nisah, K., Saminan, S., Syukri, M., Elisa, E., & Markisni, M. (2024). Optimizing of Physics Learning Through PjBL-STEM Model to Improve Critical Thinking Skills and Students Responsibility Attitudes. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1770–1778. https://doi.org/10.29303/jppipa.v10i4.6795

Patandung, Y. (2023). Adolescence Students' Critical Thinking Skills in The Context of Christian Education. *International Journal of Asian Education*, *4*(3), 150–156. https://doi.org/10.46966/ijae.v4i3.349

Prameswari, S. W., Suharno, S., & Sarwanto, S. (2018). Inculcate Critical Thinking Skills in Primary Schools. *Social, Humanities, and Educational Studies (SHEs): Conference Series*, *1*(1), 742–750. https://doi.org/10.20961/shes.v1i1.23648

Priyadi, R., Mustajab, A., Tatsar, M. Z., & Kusairi, S. (2018). Analisis Kemampuan Berpikir Kritis Siswa SMA Kelas X MIPA dalam Pembelajaran Fisika. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, *6*(1), 53. https://doi.org/10.22487/j25805924.2018.v6.i1.10020

Rasyid, I., Rohani, R., & Karo, K. (2018). Manfaat Media dalam Pembelajaran. *AXIOM: Jurnal Pendidikan dan Matematika*, *7*(1). https://doi.org/10.30821/axiom.v7i1.1778

Rianti, S., Akhsan, H., & Ismet, I. (2020). Development Modern Physics Digital Handout Based on Technology Literacy. *Berkala Ilmiah Pendidikan Fisika*, *8*(1), 23. https://doi.org/10.20527/bipf.v8i1.7593

Rositawati, D. N. (2019). Kajian Berpikir Kritis pada Metode Inkuiri. *Prosiding SNFA (Seminar Nasional Fisika dan Aplikasinya)*, *3*, 74. https://doi.org/10.20961/prosidingsnfa.v3i0.28514

Sugianto, D., Abdullah, A. G., Elvyanti, S., & Muladi, Y. (2017). Modul Virtual: Multimedia Flipbook Dasar Teknik Digital. *Innovation of Vocational Technology Education*, *9*(2). https://doi.org/10.17509/invotec.v9i2.4860

Suhada, S. (2017). Peranan Teknologi Pendidikan dalam Peningkatan Mutu Pendidikan. *Hikmah: Journal of Islamic Studies*, *13*(2), 35. https://doi.org/10.47466/hikmah.v13i2.152

Yenita, Y., Syuhendri, S., & Siahaan, S. M. (2022). Development of Conceptual Change Theory-Based E-Modules Equipped with Conceptual Change Texts on the Solar System Topics. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 1963–1973. https://doi.org/10.29303/jppipa.v8i4.1826