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Assessing Senior High School Students' Critical Thinking Skills on Global Warming in Samarinda

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Abstract

Global warming is a problem that has received attention from various countries because it can cause climate change accompanied by extreme natural disasters and threats to human health and survival on Earth. The problems of global warming will continue if not critically considered by the next generation. This study aimed to explore the level of critical thinking skills of high school students in Samarinda City and whether there are significant differences between the essential skills of thinking of public and private high school students and between male and female students. This research was an exploratory study using the survey method. The population in this study was all grade X high school students in Samarinda City, and a sample of 5 schools with details of 3 public and two private high schools totaled 274 students. The results showed that students' critical thinking skills were in the less crucial category, with the highest score on the likelihood and uncertainty analysis indicator of 63.89 and the lowest score on the problem-solving and decision-making indicator of 40.21. Public high school students demonstrated significantly higher critical thinking skills than their private school peers, while no significant difference was found between male and female students. The results of this study can be used as a reference for stakeholders to find out which indicators of critical thinking skills still need to be developed and take practical actions for the development of climate change education, especially in Samarinda. These findings highlight the need for targeted interventions to improve critical thinking skills in climate change education among high school students, particularly in Samarinda.

Keywords: critical thinking, senior high school students, global warming

INTRODUCTION

Climate change and global warming are issues that have received attention from various countries in the world, including Indonesia (Ainurrohmah & Sudarti, 2022). These phenomenons disrupt the balance of ecosystems and threaten the survival of life on Earth (Hakim et al., 2023; Harmuningsih & Saleky, 2019; Haryanti et al., 2022; Mittenzwei et al., 2019; Perdinan, 2020). Human lifestyle and environmentally destructive activities are the leading causes of this phenomenon (Ainurrohmah & Sudarti, 2022; Haryanti et al., 2022).

Several efforts must be made to reduce global warming, including inviting all parties to think critically (Rybak, 2023). Individuals who have critical thinking skills are expected to be able to assess information correctly, make convincing arguments, organize their thoughts systematically and

rationally (Astawan et al., 2023; Mao et al., 2022), analyze assumptions, evaluate, and make a decision to solve the problem (Hardika, 2020). This skill is one of the 21st-century skills (Rani et al., 2023; Mulyono et al., 2023; Silva et al., 2023; Wahyudi et al., 2023) (Mabrurah et al., 2023) and needed to face our real-life situation (Amin et al., 2017; Yuniar et al., 2022) (Syahmel & Jumadi, 2019). Developing critical thinking skills is a significant goal of education worldwide (Larsson, 2017; Yanti et al., 2023), included in science education (Efwinda et al., 2023).

The formal education system in Indonesia consists of several types of schools, such as private and public schools. These different types of schools have implications for the various curricula applied in every kind of school (Hasanah et al., 2021). Several education-related studies have examined how different types of schools affect students' skills (Hasanah et al., 2021; Pamelasari et al., 2018). In addition to differences in school types, the issue of gender differences on differences in individual critical thinking skills is still debatable. Some studies show that gender affects the level of students' critical thinking skills (Siti & Caswita, 2020; Liu & Pásztor, 2023; Nurdiana et al., 2023; Ramdani et al., 2021), but some other studies show different things that gender does not contribute differently to the level of students' critical thinking skills (Bart et al., 2015; Marni et al., 2020). Therefore, this study will also explore the level of students' critical thinking skills based on differences in school type and gender.

However, while several studies have explored critical thinking skills in topics like ecosystems (Karoror & Jalmo, 2022) and Animalia (Nugroho et al., 2022), there have been no studies specifically addressing critical thinking skills about global warming content. Therefore, this study aims to fill that gap by focusing on the critical thinking skills of high school students regarding global warming material and contributing to developing more effective global warming education.

The global warming problems will continue if the next generation does not think critically about it (Guerrero & Jesper, 2024). The expected next generation in this context is high school students. High school students must have critical thinking skills to deal with a problem, especially concerning climate change (Eilam, 2022). Exploration of the level of critical thinking skills of high school students on Global Warming Material is vital (Qiao & Zhang, 2023). An overview of students' essential level of thinking can be used as a reference for stakeholders to find out which indicators of critical thinking skills still need to be developed and take effective action to develop climate change education (Dinsmore & Fryer, 2023; Kolstø et al., 2024). However, the extent to which these critical thinking skills have developed among secondary school students, particularly in Samarinda, is still an important question that requires more attention. This is because there is limited research that specifically explores the critical thinking skills of secondary school students in understanding and responding to the issue of global warming locally, especially in Samarinda City.

The importance of critical thinking skills is currently being focused and emphasized in education (Astawan et al., 2023; M. Danil et al., 2023; Sujanem & Putu Suwindra, 2023; Suradika et al., 2023; Suresman et al., 2023). Identifying students' exploration of specific skills or skills is essential for conducting further research in developing strategies, teaching materials, media, or other things needed to improve these skills (Nazhifah et al., 2023). For example, research on the exploration of students' critical thinking skills was conducted by Karoror and Jalmo (Karoror & Jalmo, 2022), who examined ecosystem material. Other research by Nugroho et al. (Nugroho et al., 2022) on Animalia material and by Yanti et al. (2023) on Renewable Energy material. However, despite the increasing trend of research on critical thinking skills in physics (Putri et al., 2024), none of these studies have examined the Global Warming material. Critical thinking skills on this topic are necessary to be researched further. Global warming is one of the environmental issues currently sweeping all parts of the world as a form of ecological imbalance (Kiswanto, 2021), and this can threaten the sustainability of the planet where we live (Efwinda et al., 2022).

The formulation of the problems in this study includes: 1) What is the level of critical thinking of high school students in Samarinda City on Global Warming Material?; 2) Does students' critical thinking differ between public and private high schools on Global warming?; 3) Is there a difference in the critical thinking of high school students based on gender regarding global warming?

This research is a follow-up from previous research on developing critical thinking skills instruments on Global Warming Material (Maharani, 2024), which uses essential skills of thinking

indicators from Tiruneh et al. (2016). These skill indicators include 1) Hypothesis Testing, 2) Argument Analysis, Likelihood and Uncertainty Analysis, and Problem-Solving and Decision Making.

METHODS

This research is an exploratory study with a survey method that aims to obtain an overview of high school student's level of critical thinking skills in Samarinda City on Global Warming Material. The population in the study were all class X high school students in Samarinda City. The sampling technique was purposive sampling consisting of high school students in Class X from 5 schools with details of 3 public high schools and two private high schools. The sample used in the study was 274 students, with more information on 188 students from public schools and 86 from private schools.

The data collection technique used in this study used a test technique in the form of critical thinking skills questions, including four indicators: hypothesis testing, argument analysis, likelihood and uncertainty analysis, and problem-solving and decision-making. The test instrument uses the instrument from our initial research on developing critical thinking skills test instruments on global warming material (Maharani, 2024). The development of this test instrument has been tested in 5 schools in Samarinda City. The test instrument was validated by five experts, two experts, namely lecturers with expertise in science education, and 3 experts, namely physics subject teachers, achieving a reliability score of 0.750, indicating high reliability for measuring critical thinking skills in global warming topics. The test form used was 15 items in multiple-choice questions with five answer choices. To analyze the data, a normality test was conducted using the Kolmogorov-Smirnov method, followed by a T-test to examine significant differences in critical thinking skills between groups. A significance threshold of 0.05 was used to determine whether the differences were statistically significant. The results of these tests helped decide whether the null hypothesis could be rejected, indicating significant differences between the groups. The lattice of critical thinking skills test instruments can be seen in TABLE 1.

TABLE 1. Critical Thinking Skills Test Instrument

Aspects of Critical Thinking	Instrument Number
Hypothesis Testing	5, 6, and 7
Argument Analysis	1, 3, and 13
Likelihood and Uncertainty Analysis	4 and 8
Problem Solving and Decision Making	2, 9, 10, 11, 12, 14, and 15

Each indicator is linked to questions that focus on understanding global warming phenomena, the factors that cause and impact global warming, and efforts to reduce its impact. The test instrument used is dominated by HOTS questions that include various levels of cognitive dimensions, from C4 (procedural, conceptual, factual, metacognitive) to C5 (conceptual, factual, metacognitive). This dimension emphasizes students' ability to perform analysis based on existing procedures or concepts and process facts related to global warming. In some problems, students are asked to recognize problem features, adjust the solution plan accordingly, identify assumptions, and infer statements from the presented data set. This measures how students can think critically by using available information to make informed decisions. Some of the questions present problems related to daily life about global warming such as the increase of temperature in Indonesia and the impact of global warming in Samarinda City. Thus, this test instrument was designed to measure students' cognitive knowledge and their critical thinking skills in hypothesis testing, argument analysis, likelihood and uncertainty analysis, and problem-solving and decision-making related to global warming issues. FIGURE 1 and FIGURE 2 show some of the test instruments used in this study.

5. Fire at Bukit Pinang Landfill, Samarinda

For two days, parts of Samarinda City, East Kalimantan, have been covered in haze caused by a fire at the Bukit Pinang landfill site. The Head of the Samarinda Environmental Agency (DLH), Nurrahmani, explained that the cause of the fire at the Bukit Pinang landfill is extremely hazardous to humans, especially because the landfill uses an open dumping waste processing system. "This system is highly susceptible to waste combustion, so the open dumping waste processing system is also affected. Therefore, when exposed to sunlight, certain waste at the Bukit Pinang landfill is easily ignited," explained Yama, Nurrahmani's nickname.

The event described in the text above can be one of the factors contributing to the increase of greenhouse gases in the atmospheric layer. The correct answer is:

a. This event can produce greenhouse gases in the form of CH_4 sourced from decomposing waste and N_2O sourced from burning waste.
b. This event can produce greenhouse gases in the form of CO_2 sourced from decomposing piled waste.
c. This event can produce greenhouse gases in the form of CH_4 sourced from decomposing waste and from burning waste.
d. This event can produce greenhouse gases in the form of CH_4 sourced from burning waste.
e. This event can produce greenhouse gases in the form of CFCs sourced from decomposing waste and CO_2 sourced from burning waste.

FIGURE 1. Test Instrument Number 5

The test instrument in FIGURE 1 is one of the questions with critical thinking indicators of hypothesis testing. In this question, students analyze the factors that cause global warming in Samarinda City. Students are presented with an incident regarding a fire at a landfill in Bukit Pinang, Samarinda. Based on the incident, students must identify when the causal principle can be used and cannot be made; in this case, students identify the causal relationship between the garbage fire incident and the increase of greenhouse gases in the atmospheric layer. Students' conceptual knowledge of the causes of global warming by activities that produce greenhouse gas emissions is needed to answer the question.

15. Jakarta Sinking 2030

Greenpeace East Asia and Climate Central reported a prediction regarding the sinking of Jakarta in the year 2030. This prediction has become a serious issue for Indonesia because Jakarta is a region with intensive settlements and economic activities compared to other areas. Therefore, appropriate responses from both the government and the public are required to ensure that the issue of rising sea levels, which could submerge Jakarta, does not actually occur. Analyze each of the plans below as either short-term or long-term responses to the problem.

No	Effort	Short-Term	Long-Term
1.	Construction of levees in the Jakarta coastal areas		
2.	Relocation of the National Capital from Jakarta to East Kalimantan		
3.	Issuance of Regulation No. 9 of 2021 as an effort toward carbon emission reduction and mitigating the impacts of climate change		
4.	Implementing recycling systems for constructing levees, canals, and pumps		
5.	Halting groundwater extraction		

Based on the table above, the correct statement is...

A. Long-term, long-term, long-term, short-term, long-term
B. Short-term, long-term, long-term, short-term, short-term
C. Long-term, long-term, short-term, long-term, long-term
D. Long-term, short-term, long-term, short-term, long-term
E. Short-term, long-term, long-term, short-term, long-term

FIGURE 2. Test Instrument Number 15

The test instrument in FIGURE 2 is one of the questions with critical thinking indicators of problem-solving and decision-making. In the question, students presented ideas of efforts that can be made to reduce the impact of global warming. Students are presented with an issue about global warming in Indonesia regarding predictions that Jakarta will sink in 2030. Based on this problem, students must recognize the features of a problem and adjust the solution plan accordingly. In this case students identify a set of plans to overcome the problems that occur, and are categorized into long-term or short-term responses. Long-term responses are efforts that take longer to see the impact or change of the solution. Meanwhile, short-term responses are efforts that have an immediate impact. The question requires students' metacognitive knowledge about efforts to reduce the impact of global warming according to the problem given.

To answer problem number 1, namely obtaining data on the critical thinking skills of high school students in Samarinda City on the Global Warming Topic, student answers to each item were scored. After the scoring is complete, the value of critical thinking skills is calculated by referring to the following equation:

$$Value = \frac{score\ obtained}{maximum\ score} \times 100 \quad (1)$$

The score obtained represents the total correct responses, while the maximum score is the highest possible score from all questions. This formula translates students' performance into a percentage value

that is then categorized based on predefined criteria (Razak, 2017). After calculating the value of students' critical thinking skills, the value is categorized according to the criteria in TABLE 2.

TABLE 2. Categories of Critical Thinking Skills

Value	Categories
$80 \leq x \leq 100$	Very Critical
$65 \leq x < 80$	Critical
$55 \leq x < 65$	Critical Enough
$40 \leq x < 55$	Less Critical

(Razak, 2017)

To answer the formulation of problems Number 2 and 3, a different test was conducted in the form of a T-test. This T-test is also a hypothesis test of the following hypotheses.

Concerning problem number 2, the hypothesis is:

H_{O2} : There is no significant difference between the level of critical thinking skills of high school students from public and private schools.

H_{a2} : There is a significant difference between the level of critical thinking skills of high school students from public and private schools.

In connection with the formulation of problem Number 3, the hypothesis is.

H_{O3} : There is no significant difference between the critical thinking skill levels of male and female high school students.

H_{a3} : There is a significant difference between the level of critical thinking skills of male and female high school students.

Before conducting the T-test, a prerequisite test, namely the normality test, must be carried out first. A normality test is a test that needs to be done before the data is processed using a research model. The normality test aims to determine whether data distribution in a group of data or variables is usually distributed using IBM SPSS Statistics 25 with the Kolmogorov-Smirnov technique. If the significance value of the data > 0.05 (Sig. > 0.05), then the data comes from a normally distributed population. At the same time, if the significance value < 0.05 (Sig. < 0.05), the data comes from an abnormally distributed population.

After the normality test, the t-test was conducted to determine whether there were two significant differences in critical thinking skills between the two sample groups (Mardhani et al., 2022). The t-test is also the basis for deciding whether the research hypothesis can be accepted or rejected. The basis for making this test decision is by looking at the Sig. (2-tailed). If the Sig. (2-tailed) < 0.05 then the hypothesis (H0) can be rejected and the research hypothesis (H1) accepted. Meanwhile, if the value of Sig. (2-tailed) > 0.05, then the hypothesis (H0) is accepted, and the research hypothesis (H1) can be rejected.

RESULTS AND DISCUSSION

This research was conducted in 5 schools in Samarinda City. This study aimed to explore the level of critical thinking skills of high school students in Samarinda City and whether there are significant differences between the essential skills of thinking of public and private high school students and between male and female students. The following describes the critical thinking skills of high school students in Samarinda City.

Level of Critical Thinking Skills of Senior High School Students in Samarinda City

Students were given 15 multiple-choice questions on global warming material to determine their critical thinking skills. The results of the average level of critical thinking skills for each indicator can be seen in TABLE 3.

TABLE 3. Average Indicators of Students' Critical Thinking Skills

Numbers	Indicators	Average	Categories
1	*Argument analysis*	57.41	Less Critical
2	*Hypothesis testing*	50.88	Less Critical
3	*Likelihood and Uncertainty Analysis*	63.89	Critical Enough
4	*Problem-solving and Decision Making*	40.21	Very Less Critical
	Totals	48.43	Less Critical

Based on TABLE 3, it can be seen that the overall value of the acquisition of critical thinking skills is 48.43, with a less critical category. Students scored highest in Likelihood and Uncertainty Analysis, indicating some ability to assess probability, but struggled significantly with problem-solving and decision-making, highlighting a need for targeted interventions in these areas. The Likelihood and Uncertainty Analysis indicator obtained the highest score because most students could identify assumptions to get the correct statement for the given problem. The Problem solving and Decision Making indicator obtained the lowest score because some students could not recognize the features of a problem and adjust the solution plan accordingly to get the correct solution to the given problem.

This study shows that, although students can analyze possibilities and uncertainties, they face problem-solving and decision-making difficulties, primarily related to global warming material. The low scores on the Problem-solving and Decision-Making indicators indicate that students may not be fully prepared to apply critical thinking skills in complex environmental issues such as global warming. A more in-depth and relevant learning approach is needed to address this issue. For example, using case studies involving the impacts of global warming, planning mitigation solutions, and evaluating environmental policies can provide students with practical exercises in identifying and solving problems. Problem-based exercises that are concrete and relevant to environmental issues can help students understand how to apply creative and practical solutions to the challenges of global warming, as well as improve their skills in making sustainable and evidence-based decisions.

While these results provide valuable insights into the current state of students' critical thinking skills, it is crucial to consider how educational practices and curricula can be improved to address the gaps identified. Specifically, there is a need to enhance students' problem-solving and decision-making skills. This can be achieved by integrating active learning strategies, case studies, and project-based learning into the curriculum. These approaches can better engage students in real-world problem-solving, particularly in global warming and environmental issues.

Moreover, it is essential to provide professional development for teachers to equip them with effective teaching strategies that promote critical thinking, such as inquiry-based and problem-based learning. Using real-life examples and environmental topics, students will develop stronger analytical skills and better decision-making abilities, which are essential for addressing global challenges like climate change.

The concept of global warming is integrated into the learning process in a deep and multifaceted way to enhance students' critical thinking skills. In a curriculum focused on global warming, students are exposed to various simulations and models that allow them to explore the effects of different climate change scenarios. For example, students can use computer models to simulate the impact of greenhouse gas emissions on global temperatures and ecosystems and evaluate the effectiveness of mitigation solutions such as reducing emissions or planting trees. In addition, relevant case studies are often used to connect theory with practice. In these case studies, students analyze the actual impacts of global warming on specific communities or ecosystems and design mitigation strategies based on empirical data. This approach deepens students' understanding of environmental issues and trains them in evidence-based problem-solving, where they have to assess and implement relevant solutions. Interactive discussions on mitigation policies and technologies also allow students to consider multiple perspectives, develop analytical skills, and make informed decisions. By integrating global warming

into various aspects of learning, students learn about environmental impacts and hone their ability to think critically, make informed decisions and make informed decisions.

Differences in Critical Thinking Skills between Public and Private High School Students

Researchers used the independent sample T-test to measure the difference in critical thinking skills between public and private high school students. Before testing the hypothesis, the data used is tested for normality first to determine whether the data is normally distributed. The following is TABLE 4 regarding the normality test of critical thinking skills between public and private high school students.

TABLE 4. Normality Test of Critical Thinking Skills Between Public and Private High School Students

Tests of Normality

	Type School	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Results	Public High School	.157	188	.000
	Private High School	.122	86	.003

a. Lilliefors Significance Correction

TABLE 4 shows that the acquisition of significance with the Kolmogorov-Smirnov technique shows a sig value < 0.05, meaning that the data used is not normally distributed. Therefore, researchers used the Mann-Whitney U test as an alternative to the independent sample T-test. The result of the difference in critical thinking skills between public and private high school students based on the Mann-Whitney U test is 0.000, which means the value is smaller than the significance level of 0.05. This result shows that public high school students demonstrated significantly higher critical thinking skills than their private school peers.

There are differences in the essential skills of thinking of public and private high school students in conducting argument analysis, hypothesis testing, likelihood and uncertainty analysis, problem-solving, and decision-making. The two groups of students have different abilities in dealing with and solving problems related to each critical thinking indicator on global warming material. This result is supported by the research of Hasanah et al. (2021), which states that the way students answer each question indicator is influenced by school culture in science learning activities and students' experience in doing practical work. So, different learning activities in each school, such as applying effective learning models, significantly affect students' critical thinking skills.

The difference in critical thinking skills between public and private high school students depends on many interacting factors. In addition, it is necessary to consider the specific context of each school. However, generally, schools that provide an optimal learning environment, high teaching quality, and a school culture that supports critical thinking will be more effective in developing critical thinking skills in students, regardless of whether they are public or private high schools. This confirms that it is essential to identify and address the barriers in both types of schools so that all students can develop the critical thinking skills needed to understand and address global challenges such as global warming.

The integration of global warming concepts in learning in these two types of schools plays an important role in overcoming the differences in existing critical thinking skills. In curricula that include the topic of global warming, for example, students are allowed to engage in project-based activities that challenge them to analyze the impacts of climate change in local and global contexts. These projects can include field research, where students collect data regarding local carbon emissions or the success of conservation programs, as well as simulations and models that teach them about climate change and mitigation strategies. In addition, class discussions and debates on environmental policies and technological innovations also help students interactively develop critical thinking skills. Students learn to connect theoretical knowledge with everyday practice Through reflective assignments involving concrete actions, such as adopting a sustainable lifestyle or designing a carbon footprint reduction campaign. This emphasizes the importance of a supportive learning environment and high-

quality teaching to ensure that all students, whether in public or private high schools, can develop the critical thinking skills needed to face global challenges such as global warming. Therefore, identifying and addressing specific barriers in each type of school is crucial to improving learning effectiveness.

Differences in Critical Thinking Skills Based on Gender

In addition to measuring the difference in critical thinking skills between public and private high school students, researchers also measured the difference in critical thinking skills between male and female students by gender. To calculate this difference, researchers used the independent sample T-test. However, the data used was first tested for normality to determine whether the data was normally distributed or not. The following is TABLE 5 regarding the normality test of critical thinking skills based on gender.

TABLE 5. Normality Test of Critical Thinking Skills Based on Gender

Tests of Normality

		Kolmogorov-Smirnov[a]		
	Gender	Statistic	df	**Sig.**
Results	Male	.173	128	.000
	Female	.108	146	.000

a. Lilliefors Significance Correction

TABLE 5 shows that the acquisition of significance with the Kolmogorov-Smirnov technique shows a sig value <0.05, meaning that the data used is not normally distributed. Therefore, researchers used the Mann-Whitney U test as an alternative to the independent sample T-test. The acquisition of the value of differences in critical thinking skills by gender shows that the significance value of the Mann-Whitney U test is 0.753, which means the value is greater than the significance level of 0.05. This result shows no statistically significant difference between the level of critical thinking skills of male and female high school students.

Both males and females showed similar abilities in argument analysis, hypothesis testing, likelihood and uncertainty analysis, problem-solving, and decision-making. Both groups of students proved to have consistent and practical skills in dealing with and solving problems related to each critical thinking indicator on global warming material. This result is supported by the research of Hante et al. (2020), which states that there is no significant difference in critical thinking skills between male and female students, with more essential differences in other factors such as learning models and education quality. This conclusion suggests that critical thinking skills are not influenced by gender but rather by other more significant factors.

Furthermore, this study confirms that the primary concern in developing students' critical thinking skills should be improving teaching methods and the quality of educational interventions rather than gender differences. In other words, a more comprehensive approach, such as implementing active learning strategies and using learning technologies, may be a more decisive factor in promoting students' critical thinking skills. This suggests that critical thinking should be strengthened by creating an inclusive and supportive learning environment that provides equal opportunities for all students to develop essential skills of thinking, regardless of gender, optimally.

The integration of global warming concepts in the learning process contributes significantly to the development of student's critical thinking skills, regardless of gender differences. In curricula that include global warming materials, students engage in various activities that encourage them to apply analytical skills in practical ways. For example, students conduct projects focusing on climate change mitigation, such as designing a plan to reduce carbon emissions at school or evaluating the impact of environmental policies in their community. These activities allow students to apply theory in real contexts, such as using climate models to simulate the effects of different policy scenarios and formulating data-driven solutions to address climate change challenges. In addition, case studies involving the impact of global warming on local or global ecosystems provide opportunities for

students to analyze data and design relevant mitigation strategies. These activities are often integrated with discussions and debates on environmental policies, encouraging students to consider multiple perspectives and make evidence-based decisions. Learning technologies, such as climate change simulation software and interactive learning platforms, enrich students' learning experiences, strengthen their critical thinking skills, and ensure that all students have access to the latest technology.

By integrating the concept of global warming into various aspects of learning, students learn about environmental issues and develop critical thinking skills essential for analyzing and solving complex problems. These results support the finding that factors such as teaching methods and education quality affect critical thinking skills more than gender differences. Therefore, creating an inclusive learning environment and providing equal opportunities for all students to engage in problem- and technology-based learning is key to developing critical thinking skills.

This study explored the critical thinking skills of high school students in Samarinda City on global warming. The results showed that students' critical thinking skills were generally less critical, with the lowest scores in problem-solving and decision-making. Public school students demonstrated higher critical thinking skills than private school students, while no significant differences were found based on gender. The study recommends improving students' problem-solving and decision-making skills through active learning, case studies, and project-based learning. Professional development for teachers is also essential to enhance teaching strategies that promote critical thinking. Integrating global warming topics into the curriculum can also strengthen students' critical thinking skills.

The findings highlight the need for curriculum reforms and improved teaching practices to develop critical thinking skills, especially about global warming. Strengthening these skills through better teaching strategies and real-world applications will better prepare students to address global challenges like climate change.

CONCLUSION

Based on the results of the research analysis conducted, it can be concluded that:

1. The level of critical thinking skills of high school students in Samarinda City shows the acquisition of scores with an average of 48.43, which is included in the less critical category. The highest score was obtained in the Likelihood and Uncertainty Analysis indicator with a score of 63.89, which showed that most students could assess likelihood and uncertainty quite well. Conversely, the lowest score was in the problem solving and decision-making indicator, with a score of 40.21, indicating that many students struggle to recognize problems and implement effective solutions. Based on these results, related parties such as teachers need to pay more attention to facilitating the development of critical thinking skills, especially on Problem Solving and Decision-Making indicators. Future research needs to analyze what learning strategies are needed to develop students' critical thinking skills.
2. There is a statistically significant difference between the level of critical thinking skills of public and private high school students. This conclusion suggests that public high school students demonstrated significantly higher critical thinking skills than their private school peers.
3. There is no statistically significant difference between the level of critical thinking skills of male and female high school students. This conclusion suggests that critical thinking skills are not influenced by gender, but rather by other more significant factors such as teaching methods and the quality of educational interventions.

REFERENCES

Ainurrohmah, S. and Sudarti, S. (2022). Analisis Perubahan Iklim dan Global Warming yang Terjadi sebagai Fase Kritis. *Jurnal Phi Jurnal Pendidikan Fisika dan Fisika Terapan*, 3(3), pp.1–10. doi:https://doi.org/10.22373/p-jpft.v3i3.13359.

Amin, A.M., Aloysius Duran Corebima, Siti Zubaidah and Susriyati Mahanal. (2017). The Critical Thinking Skills Profile of Preservice Biology Teachers in Animal Physiology. doi:https://doi.org/10.2991/icet-17.2017.30.

Astawan, I.G., Suarjana, I.M., Werang, B.R., Asaloei, S.I., M. Sianturi and Elele, E.C. (2023). STEM-Based Scientific Learning and Its Impact on Students' Critical and Creative Thinking Skills: An Empirical Study. *Jurnal Pendidikan IPA Indonesia/JPPI* : *Jurnal Perndidikan IPA Indonesia*, 12(3), pp.482–492. doi:https://doi.org/10.15294/jpii.v12i3.46882.

Bart, W.M., Hokanson, B., Sahin, I. and Abdelsamea, M.A. (2015). An investigation of the gender differences in creative thinking abilities among 8th and 11th grade students. *Thinking Skills and Creativity*, 17, pp.17–24. doi:https://doi.org/10.1016/j.tsc.2015.03.003.

M. Danil, Corebima, A.D., S. Mahanal and I. Ibrohim. (2023). The Connection between Students' Retention and Critical Thinking Skills in Diverse Academic Skills in Biology Learning. *Jurnal Pendidikan IPA Indonesia*, 12(2), pp.241–251. doi:https://doi.org/10.15294/jpii.v12i2.39983.

Dinsmore, D. L., and Fryer, L. K. (2023). Critical thinking and its relation to strategic processing. *Educational Psychology Review*, 35(1), 36. doi:https://doi.org/10.1007/s10648-023-09755-z

Efwinda, S., Damayanti, P., Rananda, N., Puspita, I., Zahra, A.P. and Darusman, D. (2022). Pelatihan Pembuatan Poster Digital Tema Pemanasan Global untuk Siswa SMP di Samarinda. Bubungan Tinggi: *Jurnal Pengabdian Masyarakat*, 4(4), p.1132. doi:https://doi.org/10.20527/btjpm.v4i4.6183.

Eilam, E. (2022). Climate change education: the problem with walking away from disciplines. *Studies in Science Education*, 58(2), pp.1–34. doi:https://doi.org/10.1080/03057267.2021.2011589.

Siti Fauziah and None Caswita. (2020). The Analysis of Students' Mathematical Critical Thinking Skills in Terms of Gender. doi:https://doi.org/10.2991/assehr.k.200323.104.

Guerrero, G. and Jesper Sjöström. (2024). Critical scientific and environmental literacies: a systematic and critical review. *Studies in science education*, pp.1–47. doi:https://doi.org/10.1080/03057267.2024.2344988.

Hakim, A., S. Efwinda, P. Damayanti, M. Syam, O. Mutmainah and A. Norsaputra. (2023). Improving Climate Literacy of High School Students through Physics Teaching Materials based on STEM. *Jurnal Pendidikan IPA Indonesia/JPPI : Jurnal Perndidikan IPA Indonesia*, 12(4). doi:https://doi.org/10.15294/jpii.v12i4.43188.

Hante, I., Sulfikar, Jusniar. (2020). Analisis Kemampuan Berpikir Kritis Berdasarkan Gender Kelas Xi Mia Sma Negeri 1 Maiwa Melalui Model Pembelajaran Inkuiri (Studi Pada Materi Pokok Kesetimbangan Kimia). *ChemEdu* (*Jurnal Ilm. Pendidik. Kim*), 1, pp. 73–81. doi:https://doi.org/http://ojs.unm.ac.id/index.php/ChemEdu/index.

Hardika, S. (2020). Kemampuan Berfikir Kritis Matematis. Perpust. IAI Agus Salim Metro Lampung pp. 1–7. doi:https://doi.org/10.17605/OSF.IO/TJ76P.

Harmuningsih, D., Saleky, S.R.J. (2019). Pengetahuan, Persepsi dan Sikap Generasi Muda Tentang Perubahan Iklim dan Pengaruhnya Terhadap Niat Perilaku Pro-Lingkungan. *SPECTA J. Technol*. 1, pp. 27–36. doi:https://doi.org/10.35718/specta.v1i3.84.

Haryanti, N., Agus, T., Purnomo, M.W. (2022). Strategi Penanggulangan Pemanasan Global. J. Din. Ekon. Syariah 9, 15.

Hasanah, R.S., Sholihin, H., Nugraha, I. (2021). An Investigation of Junior High School Students' Science Self-Efficacy and its Correlation with Their Science Achievement in Different School Systems. *Artic. J. Sci. Learn*. 2021, pp. 192–202. doi:https://doi.org/10.17509/jsl.v4i2.27275.

Karoror, I., Jalmo, T. (2022). Profile of Critical Thinking Ability in Ecosystem Materials using the Rasch Model. *J. Penelit. Pendidik*. IPA, 8, pp.1599–1604. doi:https://doi.org/10.29303/jppipa.v8i3.1394

Kolstø, S. D., Paulsen, V. H. P. and Mestad, I. (2024). Critical thinking in the making: students' critical thinking practices in a multifaceted SSI project. *Cultural Studies of Science Education*, pp. 1-32. doi:https://doi.org/10.1007/s11422-024-10217-3

Larsson, K. (2017). Understanding and teaching critical thinking—A new approach. I*nt. J. Educ. Res.* 84, pp. 32–42. doi:https://doi.org/10.1016/j.ijer.2017.05.004.

Liu, Y. and Pásztor, A. (2023). Moderated mediating effects of gender among the components of critical thinking disposition in undergraduate students. *Heliyon*, 9(4), p.e14664. doi:https://doi.org/10.1016/j.heliyon.2023.e14664.

Mabrurah, F.F., Qadar, R., Sulaeman, N.F. (2023). Enhancing High School Students' Critical Thinking Skills through STEM-PjBL in Optics Topic. *Berk. Ilm. Pendidik. Fis*, 11 (1), pp 1-1. doi:https://doi.org/10.20527/bipf.v11i1.14068.

Maharani, J.P. (2024). Pengembangan Intrumen Tes Kemampuan Berpikir Kritis Materi Perubahan Iklim. Universitas Mulawarman.

Mao, W., Cui, Y., Chiu, M.M. and Lei, H. (2021). Effects of Game-Based Learning on Students' Critical Thinking: A Meta-Analysis. *Journal of Educational Computing Research*, 59(8), p.073563312110070. doi:https://doi.org/10.1177/07356331211007098.

Mardhani, S.D.T., Haryanto, Z., Hakim, A. (2022). Penerapan Model Problem Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis Siswa SMA. *Edufisika J. Pendidik. Fis*, 7, pp.206–213. doi:https://doi.org/https://doi.org/10.59052/edufisika.v7i2.21325.

Marni, S., Aliman, M., Roekhan, S. And Harsiati, T. (2020). Students Critical Thinking Skills Based on Gender And Knowledge Group. *Turkish Journal of Science Education*, 17(4), pp.544–560. doi:https://doi.org/10.36681/tused.2020.44.

Mittenzwei, D., Bruckermann, H., Nordine, J., Harms, U. (2019). Konsep Energi dan Kaitannya dengan Literasi Iklim 15. doi:https://doi.org/https://doi.org/10.29333/ejmste/105637.

Mulyono, Y., Suranto, Yamtinah, S. and Sarwanto. (2023). Development of Critical and Creative Thinking Skills Instruments Based on Environmental Socio-Scientific Issues: International Journal of Instruction. *International Journal of Instruction*, 16(3), pp.691–710. doi:https://doi.org/10.29333/iji.2023.16337a.

Nazhifah, N., Wiyono, K., Ismet, Azairok, M. (2023). Profile of Physics Creative Thinking Skills for High School Students in The 21st Century. *JIPFRI (Jurnal Inov. Pendidik. Fis. dan Ris. Ilmiah)*,7, pp.1–11. doi:https://doi.org/10.30599/jipfri.v7i1.2131

Nugroho, A.T., Karyanto, P. and Sugiharto, B. (2022). Profile of Critical Thinking Ability of High School Students on Animalia Material During Hybrid Learning in the Pandemic Era. *Jurnal Penelitian Pendidikan IPA*, 8(6), pp.2635–2640. doi:https://doi.org/10.29303/jppipa.v8i6.1809.

Nurdiana Nurdiana, Hunaepi Hunaepi, Muhammad Ikhsan, Hadi Suwono and Sulisetijono Sulisetijono (2023). Exploring curiosity and critical thinking skills for prospective biology teacher. *International Journal of Evaluation and Research in Education*, 12(1), pp.131–131. doi:https://doi.org/10.11591/ijere.v12i1.23302.

Pamelasari, S.D., Nurkhalisa, S. and Laksmana, S.I. (2018). A comparison study of instruction between international school and state school of middle school level in Indonesia. *Journal of Physics: Conference Series*, 983, p.012204. doi:https://doi.org/10.1088/1742-6596/983/1/012204.

Perdinan, P. (2020). Perubahan Iklim Dan Demokrasi: Ketersediaan Dan Akses Informasi Iklim, Peranan Pemerintah, Dan Partisipasi Masyarakat Dalam Mendukung Implementasi Adaptasi Perubahan Iklim Di Indonesia. J*urnal Hukum Lingkungan Indonesia*, 1(1), p.109. doi:https://doi.org/10.38011/jhli.v1i1.87.

Putri, S.A., Nisa, K., Kuswanto, H. (2024). Trends of Physics Critical Thinking Skill Research in Indonesia: A Systematic Literature Review. *J. Penelit. Pengemb. Pendidik. Fis*, 10, pp.1–14. doi:https://doi.org/10.21009/1.10101.

Qiao, H. and Zhang, J. (2023). Enhancing global thinking can reduce the misconception of accumulation: A potential way to mitigate climate change. *Environmental Science and Pollution Research*, 30(20), pp.58618–58629. doi:https://doi.org/10.1007/s11356-023-26510-7.

Ramdani, A., Jufri, A.W., Gunawan, G., Fahrurrozi, M. and Yustiqvar, M. (2021). Analysis of Students' Critical Thinking Skills in terms of Gender Using Science Teaching Materials Based on The 5E Learning Cycle Integrated with Local Wisdom. *Jurnal Pendidikan IPA Indonesia*, 10(2), pp.187–199. doi:https://doi.org/10.15294/jpii.v10i2.29956.

Rani Asmara, Siti Zubaidah, Susriyati Mahanal and Sari, N. (2023). Levels of Inquiry and Reading-Questioning-Answering (LoIRQA) to Enhance High School Students' Critical and Creative Thinking. *International Journal of Instruction*, 16(3), pp.325–342. doi:https://doi.org/10.29333/iji.2023.16318a.

Razak, F. (2017). Hubungan Kemampuan Awal Terhadap Kemampuan Berpikir Kritis Matematika Pada Siswa Kelas VII SMP Pesantren Immim Putri Minasatene. *J. Mosharafa*, 6, pp.117–128.

Rybak, K. (2023). Towards A Literature of Actions: Green Informational Picturebooks and Critical Engagement with Fighting Climate Change. *Children's Literature in Education*, 1-15. doi:https://doi.org/10.1007/s10583-023-09549-5.

Silva, H., Lopes, J., Morais, E. and Dominguez, C. (2023). Fostering Critical and Creative Thinking through the Cooperative Learning Jigsaw and Group Investigation. I*nternational Journal of Instruction*, 16(3), pp.261–282. doi:https://doi.org/10.29333/iji.2023.16315a.

Sujanem, R., Putu Suwindra, I.N. (2023). Problem-Based Interactive Physics E-Module in Physics Learning Through Blended Pbl To Enhance Students' Critical Thinking Skills. *J. Pendidik. IPA Indones*, 12, pp.135–145. doi:https://doi.org/10.15294/jpii.v12i1.39971.

Suradika, A., Dewi, H.I. and Nasution, M.I. (2023). Project-Based Learning and Problem-Based Learning Models in Critical and Creative Students. *Jurnal Pendidikan IPA Indonesia*, 12(1). doi:https://doi.org/10.15294/jpii.v12i1.39713.

Suresman, E., Febrianti, F.A., Dallyono, R. (2023). Implementation of i-Spring Suite to improve students' learning for critical thinking skills in natural science. *Cakrawala Pendidik*, 42, pp.433–446. doi:https://doi.org/10.21831/cp.v42i2.53646

Syahmel, S. and Jumadi, J. (2019). Discovery Learning using Multiple Representation model for enhancing scientific processing and critical thinking skills of the students. *Jurnal Inovasi Pendidikan IPA*, 5(2). doi:https://doi.org/10.21831/jipi.v5i2.26704.

Tiruneh, D.T., De Cock, M., Weldeslassie, A.G., Elen, J. and Janssen, R. (2016). Measuring Critical Thinking in Physics: Development and Validation of a Critical Thinking Test in Electricity and Magnetism. I*nternational Journal of Science and Mathematics Education*, 15(4), pp.663–682. doi:https://doi.org/10.1007/s10763-016-9723-0.

Wahyudi, A., Richardo, R., Eilks, I. and Kulgemeyer, C. (2023). Development of Three Tier Open-Ended Instrument to Measure Chemistry Students' Critical Thinking Disposition Using Rasch Analysis. *International Journal of Instruction*, 16(3), pp.191–204. doi:https://doi.org/10.29333/iji.2023.16311a.

Yanti Yuliarti, Leni Marlina, Sardianto Markos Siahaan, Apit Fathurohman and Sudirman Sudirman (2023). Profile of High School Students' Critical Thinking Skills about Renewable Energy Materials. *Jurnal Penelitian Pendidikan IPA*, 9(11), pp.10151–10160. doi:https://doi.org/10.29303/jppipa.v9i11.5418.

Yuniar, R., Nurhasanah, A., Rahman Hakim, Z., Asih Vivi Yandari, I. (2022). Peran Guru dalam Pelaksanaan Model Pbl (Problem Based Learning) Sebagai Penguatan Keterampilan Berpikir

Kritis. *Pendas Jurnal Ilmiah Pendidikan Dasar*, 7, pp.1134–1150. doi:https://doi.org/10.23969/jp.v7i2.6408.