Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

April 2025. Vol. 13, No. 2
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 283-293

Identifying Analytical Thinking Skills in Forestry Students: Understanding Climate Change Awareness in the 21st Century Context

Muhali, *Hulyadi, Khaeruman, Gargazi, Irham Azmi
Faculty of Engineering and Applied Science, Universitas Pendidikan Mandalika. Jl. Pemuda No. 59A, Mataram 83125, Indonesia.

*Corresponding Author e-mail: hulyadi@undikma.ac.id

Received: November 2024; Revised: March 2025; Published: April 2025

Abstract

Climate change is a critical global issue with complex and far-reaching impacts that extend beyond the environment to include social, economic, and health dimensions. Addressing these challenges requires future professionals, such as forestry students, to develop strong analytical thinking skills, particularly in identifying and formulating environmental problems. Despite the growing recognition of climate change, limited research exists on forestry students' understanding and analytical response to this issue, especially within specific regional contexts such as West Nusa Tenggara (NTB), Indonesia—a region particularly vulnerable to climate-related effects. This study aims to examine the level of awareness among forestry students regarding climate change issues in NTB and to evaluate their problem-identification and problem-formulation skills based on the phenomenon of global warming in the area. The novelty of this research lies in its regional focus, as NTB is seldom featured in climate literacy studies despite its unique climatic challenges. Using a descriptive quantitative method, data were collected from 26 forestry students enrolled in a Basic Chemistry course through an essay-based test administered in October. The variables observed were environmental awareness, problem-formulating ability, and problem-identifying ability. Data analysis was conducted descriptively and presented in tables and graphs. Results showed low student performance across all variables, with mean scores of 44.6 (awareness), 50.96 (problem formulation), and 40.76 (problem identification). These findings underscore the urgent need for strategic, problem-based educational approaches to improve students' climate awareness and analytical competencies, ultimately preparing them to effectively contribute to sustainable environmental solutions in their future professional roles.

Keywords: Analytical Thinking; Climate Change Awareness; Forestry Education; Problem Identification; Environmental Literacy

How to Cite: Muhali, M., Hulyadi, H., Khaeruman, K., Gargazi, G., & Azmi, I. (2025). Identifying Analytical Thinking Skills in Forestry Students: Understanding Climate Change Awareness in the 21st Century Context. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 13*(2), 283-293. doi:https://doi.org/10.33394/j-ps.v13i2.13644

https://doi.org/10.33394/j-ps.v13i2.13644

INTRODUCTION

Climate change is no longer a future threat but a present reality with direct impacts on various sectors, including global health and socio-economic resilience (Abbass et al., 2022; Ülker et al., 2018). This phenomenon has triggered global temperature increases, shifts in weather patterns, rising sea levels, and complex environmental degradation. One of the most concerning effects is the excessive formation of free radicals, increased oxidative stress in living organisms, and significant pressure on socio-economic systems (Haines et al., 2006; Kim et al., 2014; Zhao et al., 2022).

Free radicals are unstable molecules capable of damaging cells and tissues. While the human body has mechanisms to counteract their effects (Agita & Alsagaff, 2017; Chaudhry & Sidhu, 2022), climate change and increasing environmental pollution generate excessive

amounts of free radicals, overwhelming the body's antioxidant systems (Salvi et al., 2001). Prolonged exposure to high levels of free radicals is linked to chronic diseases such as cancer, cardiovascular disorders, neurodegenerative diseases, and premature aging. This oxidative stress places a significant burden on global public health systems, particularly in developing countries with limited medical resources (Gebicki, 2016; Lushchak, 2014; Nakai & Tsuruta, 2021). Rising incidences of cancer, hypertension, and COVID-19 are among the health challenges exacerbated by oxidative stress from free radical exposure.

Additionally, climate change has profoundly impacted global food security, reducing agricultural productivity due to extreme weather, altered rainfall patterns, and increased pest and microbial infestations (Mukherjee, 2021; Tai et al., 2014). Consequently, food prices have risen, and instability in food supplies has worsened, especially in impoverished countries heavily reliant on local agriculture. Fragile food security exacerbates socio-economic inequality, heightens malnutrition risks, and increases dependency on food aid. (Haines et al., 2006; Ibáñez et al., 2023; Kim et al., 2014) report that climate change accelerates the growth rate of pathogenic microbes and facilitates the spread of previously uncommon or geographically confined diseases. Higher temperatures and humidity promote the proliferation of microorganisms, including bacteria, fungi, and viruses, threatening global health.

The economic losses from climate change—such as rising healthcare costs, productivity losses due to illness, and strain on socio-economic resources—are immense. Countries with weak economies and low healthcare capacity bear the brunt of these effects. As climate change continues to destabilize socio-economic systems, governments face mounting pressure to provide health, economic, and food assistance, creating a difficult cycle to break without sustainable interventions.

Given the global impacts of climate change, integrating climate change into academic curricula is essential to equip students with the competencies and skills to address 21st-century complexities (Cheung, 2024; Singh et al., 2022). Students, particularly those of Generation Z, must be trained to adapt to these challenges. Generation Z, born between 1997 and 2012, is expected to play a pivotal role in realizing Indonesia's Golden Vision 2045. However, concerns arise regarding their perceived lack of resilience, tendency toward boredom, and work ethic often considered less rigorous. These challenges spark critical discussions about their readiness to face increasingly fierce global competition. This study aims to identify the underlying factors contributing to these characteristics and offer recommendations to maximize the potential of Generation Z in achieving Indonesia Emas 2045 (Hendrastomo & Januarti, 2023).

Generation Z' essential role in preparing for Indonesia Emas underscores the need to train and strengthen their character in tackling the complexities of the 21st century. Addressing these challenges requires students to develop skills in problem mapping, problem formulation, conducting literature reviews, and categorizing issues (Chamidy et al., 2020; Hulyadi et al., 2023). Problem-solving skills are fundamental competencies that must be cultivated to face global challenges and contribute to the realization of Indonesia Emas.

One of the key high-order thinking skills to develop is analytical thinking (Brandt & Lorié, 2024). Analytical thinking involves a scientifically driven thought process. In the fast-paced changes of the 21st century—spanning technology, economics, and socio-cultural dynamics—individuals need to adapt swiftly and effectively. Analytical thinking helps individuals understand problems deeply and enables more precise problem mapping, resulting in accurate solutions. In an era marked by rapid technological and social changes, analytical thinkers are better equipped to process new information, evaluate its relevance, and adjust their actions accordingly. This ability is vital for a modern workforce required to stay ahead of technological advancements and new work methods (Hulyadi et al., 2024).

Creative and innovative solutions are highly valued in the 21st century, especially in the professional and business world. Analytical thinking provides a strong foundation for developing effective and innovative solutions. It enables individuals to explore problems from

multiple perspectives, consider various possible solutions, and devise unique approaches to challenges. This competency is particularly relevant in industries that demand out-of-the-box solutions and value-added products for consumers (Gelen, 2018). Collaboration is another crucial aspect of the modern world. Analytical thinking helps individuals understand diverse perspectives within a team, make objective assessments of proposed ideas, and integrate thoughts into more effective collective solutions. Successful collaboration relies on the ability to analyze and synthesize ideas from team members with different backgrounds and expertise (Muhajir et al., 2019; Perdanasari et al., 2021).

Abbass et al. (2022) and Chaudhry and Sidhu (2022) report that climate change has been proven to cause significant multidimensional impacts, including disruptions to health, food security, and global socio-economic systems. Nevertheless, there remains a lack of research examining how students—particularly Generation Z, who are expected to be key actors in achieving Indonesia's Golden Vision 2045—respond to the complexity of environmental issues through analytical thinking skills. Specifically, there is still insufficient empirical data on the level of student awareness regarding climate change and its impacts on health, society, and the economy, especially within local contexts such as Eastern Indonesia. Furthermore, the extent to which students' abilities to identify and formulate environmental problems reflect the analytical thinking skills needed to address 21st-century challenges remains unclear. Additionally, the underlying factors contributing to the lack of analytical thinking in the context of climate change, and how learning strategies can be adapted to address this issue, have not been adequately explored.

This study integrates climate change issues with biomedical impacts (such as oxidative stress caused by free radicals), food security, and socio-economic pressures—an approach that remains rare in higher education research in Indonesia. The research specifically highlights the preparedness and competence of Generation Z, who represent the backbone of Indonesia's future human resources, in facing the challenges of climate change by strengthening high-order thinking skills. This study directly assesses students' ability to identify and formulate environmental problems as indicators of analytical thinking—an essential skill that is still rarely evaluated explicitly in climate change–oriented curricula. The local context of Eastern Indonesia (specifically NTB) as the study site—focusing on global warming and environmental issues in a geographically vulnerable but under-researched region—offers a meaningful contribution to local literature and context-based educational strategies.

Errors in problem identification are among the primary barriers to effective solutions. Misidentified problems can lead to ineffective solutions or even exacerbate existing issues. Analytical thinking enables systematic and accurate problem identification, ensuring that solutions are well-suited to the existing challenges (Dörner & Güss, 2022; Kenney et al., 2020). Analytical thinking is not just a skill needed in specific academic or professional fields but is a fundamental competence for navigating modern life's complexities. It enables individuals to understand, analyze, and address everyday challenges and professional demands more effectively. In preparing for the challenges of the 21st century and Indonesia Emas 2045, fostering analytical thinking skills among students is essential. Equipping them with these competencies ensures they are ready to adapt to complex problems and contribute meaningfully to a sustainable and prosperous future.

METHOD

This study employs a descriptive quantitative approach. It aims to systematically and factually describe phenomena as they exist, specifically focusing on students' analytical thinking abilities assessed through various indicators. The population in this study consists of 60 forestry students enrolled in the Basic Chemistry course. Given the manageable population size, the research uses a total sampling or census technique, in which all members of the population are included as the sample.

The variable in this study is the students' analytical thinking ability, measured through a specially designed instrument to assess analytical skills in problem-solving contextualized to the challenges of the 21st century. The instrument also incorporates questions that evaluate students' environmental awareness. The instrument used in this research is an essay test that has undergone a validation process. The test is designed to measure aspects of students' analytical thinking abilities, such as problem identification, logical reasoning, conclusion-making, and problem-solving. As this is a preliminary study, the variable is limited to students' ability to identify problems, which serves as the foundational element of analytical thinking. An additional indicator, environmental awareness, is also included in the study.

The data obtained from the test results will be analyzed quantitatively using descriptive statistical techniques. Data analysis begins with scoring each response based on a predetermined scoring rubric. Subsequently, the average scores and frequency distribution are calculated to examine the distribution of students' analytical thinking abilities. Based on the analysis results, interpretations are made to describe students' analytical thinking skills.

RESULTS AND DISCUSSION

Understanding problems through systematic and scientific identification processes is the cornerstone of higher-order thinking skills (HOTS). In the context of education and personal development, this ability is not merely an individual advantage but a necessity in addressing today's complex challenges (Liline et al., 2024). Problem identification is the initial stage in problem-solving that involves observation and analysis of a specific situation to pinpoint core aspects requiring solutions. Within a scientific framework, problem identification is conducted through structured methods such as data collection, fact analysis, and the formulation of logical hypotheses or assumptions (Aslan, 2021; Yayuk et al., 2020).

According to Dörner & Güss (2022), data collection and fact analysis are key components in formulating accurate hypotheses. In the scientific process, these steps serve as a foundation enabling researchers or problem-solvers to develop hypotheses that are not only logical but also evidence-based. Rahman (2019) emphasizes that data collection is a systematic process of obtaining relevant information from various sources to answer research questions or resolve problems. Data can be gathered through several methods, including experiments, surveys, observations, and interviews. This factual basis minimizes speculation or inaccurate assumptions.

In this study, data were collected through interviews and essay tests. The data on students' analytical thinking skills were categorized based on indicators such as their ability to identify, analyze, and gather data related to the contextual problems presented. A summary of students' analytical thinking competencies is depicted in Figure 1.

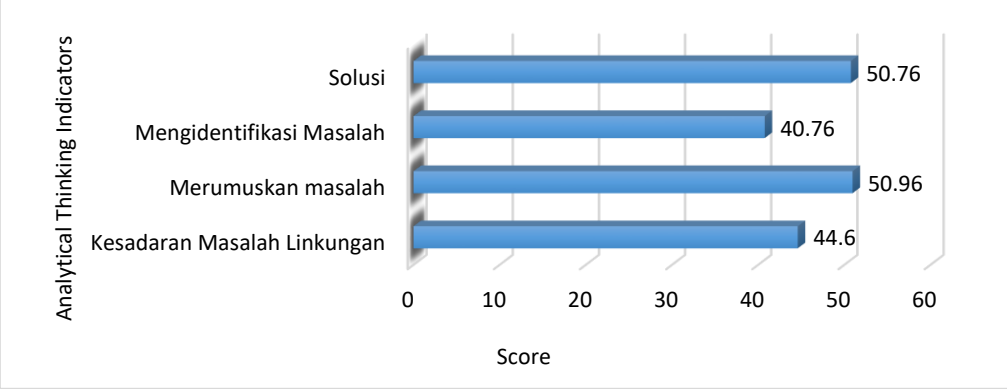

Figure 1. Students' analytical thinking competencies

Preliminary findings from the initial study indicate that forestry students' awareness of environmental issues remains low. The research focused on the global warming issue, which

drives current climate change. Forestry students at UNDIKMA show limited awareness, as external environmental cues, such as the intensely hot temperatures experienced when the instruments were distributed, were not perceived as part of the ongoing environmental challenges. In October, NTB recorded its highest temperature, reaching 37°C. Not all students recognized this extreme heat as an indicator of climate change, a pressing global issue today.

According to Turpyn & Adiwitya (2021), climate change is a significant problem that must be acknowledged due to its impact across various sectors at international, regional, national, and local levels. Climate change triggers extreme weather events and disasters, which are detrimental to society at large. However, public awareness of the adverse effects of climate change remains low, largely due to a lack of knowledge on the subject.

It is crucial for UNDIKMA forestry students to have a heightened awareness of environmental changes caused by climate change. Awareness serves as the initial foundation for problem-solving. From recognizing environmental issues, students can begin identifying visible indicators of climate change, determining its primary causes, and proposing solutions. Chaudhry & Sidhu (2022) and Cheung (2024) highlight that climate change has become a global issue with significant impacts on ecosystems and human life. This phenomenon exacerbates extreme weather, biodiversity loss, land degradation, and an increasing frequency of natural disasters. Abbass et al. (2022) also state that public awareness of the impacts of climate change remains low, primarily due to insufficient knowledge on the matter.

As agents of change, forestry students bear a significant responsibility to understand and respond to environmental shifts caused by climate change. Their awareness is a critical foundation for analyzing impacts, identifying indicators of change, and devising sustainable solutions (Abbass et al., 2022; Chaudhry & Sidhu, 2022). Many forestry students lack a comprehensive understanding of climate change concepts, such as the greenhouse effect mechanism, the role of carbon emissions, and the interactions between climate change and forest ecosystems. This lack of understanding was evident in the preliminary study conducted in October 2024. The findings are presented in Figure 2 below.

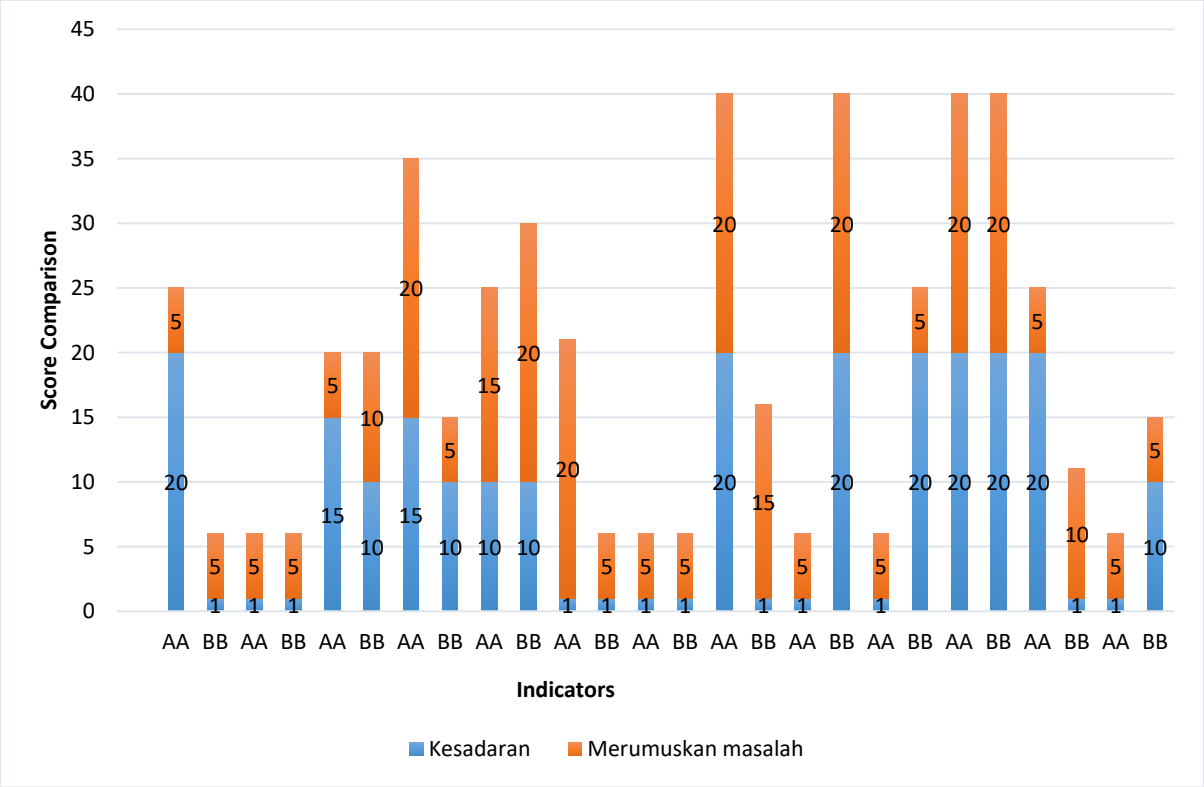

Figure 2. Description of Students' Awareness and Ability to Formulate the Core Issues Behind Climate Change

Figure 2 illustrates the low levels of awareness and ability among students to identify and formulate the primary issues contributing to climate change. Despite the global impacts of climate change, many students remain unaware of its tangible effects at the local level, such as the increased frequency of floods, forest fires, or reduced water availability in forest areas (Cheung, 2024; Turpyn & Adiwitya, 2021). Some students view environmental issues as the responsibility of the government or specific organizations, rather than a collective challenge. As a result, participation in climate change mitigation and adaptation activities tends to be low (Idil & Kocak, 2024).

Forestry education often emphasizes theoretical knowledge over practical fieldwork. Consequently, students lack hands-on experience in monitoring or identifying climate change indicators in forest ecosystems. It is essential to instill in students the understanding that everyone plays a role in contributing to climate change. For example, almost all lecturers and students commute to campus using fossil fuel-powered vehicles, which are major contributors to the global climate crisis. Raising this awareness can foster a sense of shared responsibility among students to propose solutions, ranging from simple to complex. To enhance forestry students' environmental awareness and competence, it is important to introduce observable climate change indicators in their immediate surroundings. Students should record irregular rainfall patterns, which can affect forest vegetation growth and hydrological cycles. Irregular rainfall patterns pose significant challenges to forestry and agriculture sectors (Box et al., 2019). Global climate change has altered the temporal and spatial distribution of rainfall, shifting hydrological cycles and impacting ecosystem productivity (Donnelly et al., 2004).

For forestry students, understanding these dynamics is a crucial skill to support data-driven and sustainable decision-making (Hatfield et al., 2020). Addressing these challenges requires mastering several fundamental competencies, including analytical, technical, and managerial skills to study rainfall patterns and their impacts on forest ecosystems and agriculture (Brandt & Lorié, 2024; Ramakrishnan, 2022). Competencies such as understanding the basics of hydrological cycles, rainfall distribution, weather pattern factors, and interpreting climatological data—such as precipitation, humidity, and temperature—are critical for students. Higher-order thinking skills are necessary to master these complex and interrelated competencies. Analytical thinking helps students identify problems and seek creative solutions. Students' ability to identify issues, link facts, and interpret empirical evidence from communicative data should be continuously developed to enhance this competency (Muhajir et al., 2019). This skill is crucial for students amid the complexities of 21st-century challenges (Hulyadi et al., 2024; Perdanasari et al., 2021).

Issues such as rising temperatures can accelerate evaporation processes, disrupt forest ecosystem balances, and threaten flora and fauna species. Climate change causes certain forest species to fail to adapt to new conditions, potentially leading to extinction. In coastal areas, these effects may result in saltwater intrusion into mangrove ecosystems, disrupting their role as wave buffers and fish spawning grounds. The complexity of climate change-related problems underscores the importance of mastering analytical thinking as a fundamental skill (Rahman, 2019). In the 21st century, students must develop problem-solving abilities as the world continues to face increasingly complex challenges (Dörner & Güss, 2022; Yayuk et al., 2020). Unfortunately, the rapid development of these issues often outpaces the ability of many individuals to devise effective solutions. Solutions are only effective and accurate when problems are identified critically, in detail, and with precision. The research findings indicate that students' ability to identify problems in a detailed, accurate, and critical manner remains low, as described in Figure 3.

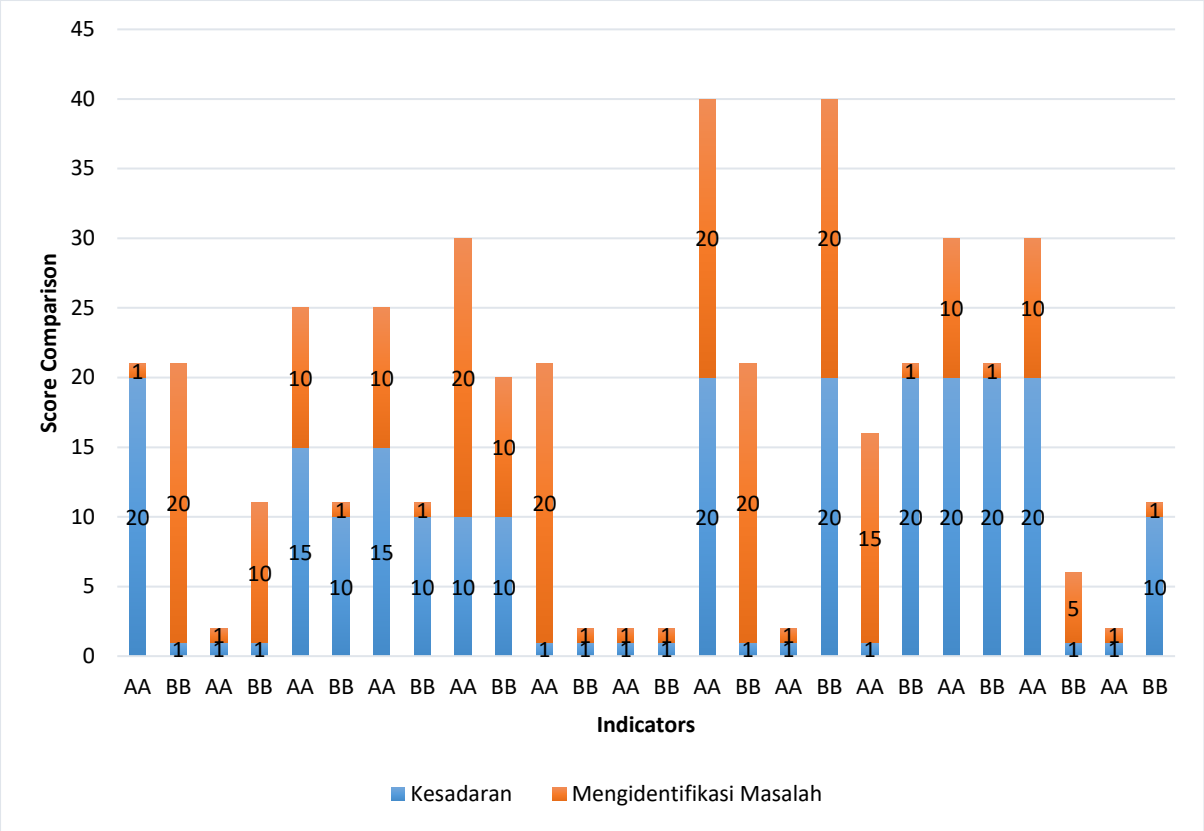

Figure 3. Student awareness and competence in identifying environmental problems.

The ability to identify problems is the cornerstone of the problem-solving process. This philosophy is based on the principle that a well-defined problem is halfway to its solution (Dörner & Güss, 2022). Accurate problem identification enables subsequent steps to be more focused, efficient, and effective. Without proper identification, problem-solving efforts often fail to produce results or may even create new issues (Nickerson et al., 2012; Okes, 2019). A problem is defined as the gap between the current state and the desired state. This gap can manifest as obstacles, challenges, or unmet needs. Figure 3 highlights the low ability of students to identify problems. Research findings reveal that this weakness stems from the lack of awareness among students about environmental issues caused by climate change. For instance, in exploring the extreme temperatures in NTB, which reached 37°C in October 2024—a condition unprecedented in recent years—the researchers aimed to raise awareness among forestry students at UNDIKMA about the tangible impacts of climate change. This extreme heat has often been the subject of complaints from the NTB community.

The researchers hoped that by addressing environmental issues, students' awareness of climate change could be increased. Preliminary results indicate that approximately 50% of students failed to recognize NTB's extreme heat as a global climate change indicator. Raising this awareness is crucial to building a consensus that environmental issues are a collective problem and must be addressed collaboratively. Problem identification is the most critical step in the problem-solving process. With a precise problem definition, solution steps can be designed more efficiently and effectively (Aslan, 2021). Conversely, failure to identify problems accurately leads to wasted resources and the potential emergence of new issues. Therefore, developing problem-identification skills should be a primary focus in education, training, and professional practice (Dörner & Güss, 2022). Forestry students who are skilled in analyzing irregular rainfall patterns will become valuable assets for sustainable natural resource management. They need a combination of theoretical understanding, technical skills, and practical approaches to provide holistic solutions. Investing in the development of these

competencies will not only support the forestry and agricultural sectors but also contribute to mitigating the global impacts of climate change.

CONCLUSION

This study indicates that forestry students' awareness of environmental issues, particularly climate change, is at a low level, with an average score of 44.6. Furthermore, their ability to formulate environmental issues scored an average of 50.96, while their ability to identify problems scored only 40.76. These findings suggest that students lack adequate analytical thinking skills to address climate change challenges. Therefore, strategic steps are necessary to enhance students' awareness and analytical abilities regarding environmental issues.

RECOMMENDATIONS

Based on the preliminary findings, the researcher recommends integrating climate change issues into relevant courses, particularly in the local context, such as the impact of climate change on specific regions. The development of problem-based learning modules is suggested to train students' analytical and decision-making skills. A scientific fundamental approach to learning should be applied to train analytical thinking skills. Learning approaches that focus on problem exploration, tracing root causes, and identifying the core issues should be systematically packaged. The researcher recommends the *Question Map* learning approach, which is expected to help uncover problems down to their roots. It is also important to involve students in real-world projects related to climate change mitigation to enhance their practical experience. One such effort is providing skills in processing organic resources or biomass into green energy sources**.**

ACKNOWLEDGMENT

The research team would like to express its gratitude to the Mandalika University of Education UNDIKMA for providing facilities and financial assistance so that the research can proceed well and according to expectations.

REFERENCES

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*, *29*(28), 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Agita, A., & Alsagaff, M. T. (2017). Inflammation, Immunity, and Hypertension. *Acta Medica Indonesiana*, *49*(2), Article 2.

Aslan, A. (2021). Problem- based learning in live online classes: Learning achievement, problem-solving skill, communication skill, and interaction. *Computers & Education*, *171*, 104237. https://doi.org/10.1016/j.compedu.2021.104237

Box, J. E., Colgan, W. T., Christensen, T. R., Schmidt, N. M., Lund, M., Parmentier, F.-J. W., Brown, R., Bhatt, U. S., Euskirchen, E. S., Romanovsky, V. E., Walsh, J. E., Overland, J. E., Wang, M., Corell, R. W., Meier, W. N., Wouters, B., Mernild, S., Mård, J., Pawlak, J., & Olsen, M. S. (2019). Key indicators of Arctic climate change: 1971–2017. *Environmental Research Letters*, *14*(4), 045010. https://doi.org/10.1088/1748-9326/aafc1b

Brandt, W. C., & Lorié, W. (2024). *Measuring Student Success Skills: A Review of the Literature on Analytical Thinking. Competencies of the Future*. National Center for the Improvement of Educational Assessment. https://eric.ed.gov/?id=ED660549

Chamidy, T., Degeng, I. N. S., & Ulfa, S. (2020). The Effect of Problem-Based Learning and Tacit Knowledge on Problem-Solving Skills of Students in Computer Network Practice

Course. In *Online Submission* (Vol. 8, Issue 2, pp. 691–700). https://eric.ed.gov/?id=ED606218

Chaudhry, S., & Sidhu, G. P. S. (2022). Climate change regulated abiotic stress mechanisms in plants: A comprehensive review. *Plant Cell Reports*, *41*(1), 1–31. https://doi.org/10.1007/s00299-021-02759-5

Cheung, K. K. C. (2024). A Structural Model of Future-Oriented Climate Change Optimism in Science Education: PISA Evidence from Countries with Top Environmental Protection Index. *Research in Science Education*, *54*(5), 845–865. https://doi.org/10.1007/s11165-024-10164-7

Donnelly, A., Jones, M. B., & Sweeney, J. (2004). A review of indicators of climate change for use in Ireland. *International Journal of Biometeorology*, *49*(1), 1–12. https://doi.org/10.1007/s00484-004-0215-5

Dörner, D., & Güss, C. D. (2022). Human error in complex problem solving and dynamic decision making: A taxonomy of 24 errors and a theory. *Computers in Human Behavior Reports*, *7*, 100222. https://doi.org/10.1016/j.chbr.2022.100222

Gebicki, J. M. (2016). Oxidative stress, free radicals and protein peroxides. *Archives of Biochemistry and Biophysics*, *595*, 33–39. https://doi.org/10.1016/j.abb.2015.10.021

Gelen, I. (2018). ACADEMICIANS' PREDICTIONS OF 21st CENTURY EDUCATION AND EDUCATION IN THE 21st CENTURY. *European Journal of Education Studies*, *0*, Article 0. https://doi.org/10.46827/ejes.v0i0.1597

Haines, A., Kovats, R. S., Campbell-Lendrum, D., & Corvalan, C. (2006). Climate change and human health: Impacts, vulnerability and public health. *Public Health*, *120*(7), 585–596. https://doi.org/10.1016/j.puhe.2006.01.002

Hatfield, J. L., Antle, J., Garrett, K. A., Izaurralde, R. C., Mader, T., Marshall, E., Nearing, M., Philip Robertson, G., & Ziska, L. (2020). Indicators of climate change in agricultural systems. *Climatic Change*, *163*(4), 1719–1732. https://doi.org/10.1007/s10584-018-2222-2

Hendrastomo, G., & Januarti, N. E. (2023). The Characteristics of Generation Z Students and Implications for Future Learning Methods. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *9*(2), 484–496. https://doi.org/10.33394/jk.v9i2.7745

Hulyadi, H., Bayani, F., Ferniawan, Rahmawati, S., Liswijaya, Wardani, I. K., & Swati, N. N. S. (2024). Meeting 21st-Century Challenges: Cultivating Critical Thinking Skills through a Computational Chemistry-Aided STEM Project-Based Learning Approach. *International Journal of Contextual Science Education*, *1*(2), 57–64. https://doi.org/10.29303/ijcse.v1i2.609

Hulyadi, H., Bayani, F., Muhali, M., Khery, Y., & Gargazi, G. (2023). Correlation Profile of Cognition Levels and Student Ability to Solve Problems in Biodiesel Synthesis. *Jurnal Penelitian Pendidikan IPA*, *9*(6), Article 6. https://doi.org/10.29303/jppipa.v9i6.3130

Ibáñez, A., Garrido-Chamorro, S., & Barreiro, C. (2023). Microorganisms and Climate Change: A Not So Invisible Effect. *Microbiology Research*, *14*(3), Article 3. https://doi.org/10.3390/microbiolres14030064

Idil, S., & Kocak, O. (2024). The Reflections of the "Stop Climate Change Digital Game" on Primary School Students' Learning about Climate Change. *Journal of Education in Science, Environment and Health*, *10*(1), 18–31.

Kenney, R., An, T., Kim, S.-H., Uhan, N. A., Yi, J. S., & Shamsul, A. (2020). Linear Programming Models: Identifying Common Errors in Engineering Students' Work with Complex Word Problems. *International Journal of Science and Mathematics Education*, *18*(4), 635–655. https://doi.org/10.1007/s10763-019-09980-5

Kim, K.-H., Kabir, E., & Ara Jahan, S. (2014). A Review of the Consequences of Global Climate Change on Human Health. *Journal of Environmental Science and Health, Part C*, *32*(3), 299–318. https://doi.org/10.1080/10590501.2014.941279

Liline, S., Tomhisa, A., Rumahlatu, D., & Sangur, K. (2024). The Effect of the Pjb-HOTS Learning Model on Cognitive Learning, Analytical Thinking Skills, Creative Thinking Skills, and Metacognitive Skills of Biology Education Students. *Journal of Turkish Science Education*, *21*(1), 175–195.

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, *45*, 101069. https://doi.org/10.1016/j.tsc.2022.101069

Liu, Y., Xi, D.-G., Li, Z.-L., & Shi, C.-X. (2014). Analysis and Application of the Relationship between Cumulonimbus (Cb) Cloud Features and Precipitation Based on FY-2C Image. *Atmosphere*, *5*(2), Article 2. https://doi.org/10.3390/atmos5020211

Lushchak, V. I. (2014). Free radicals, reactive oxygen species, oxidative stress and its classification. *Chemico-Biological Interactions*, *224*, 164–175. https://doi.org/10.1016/j.cbi.2014.10.016

Muhajir, S. N., Utari, S., & Suwarma, I. R. (2019). How to develop test for measure critical and creative thinking skills of the 21st century skills in POPBL? *Journal of Physics: Conference Series*, *1157*(3), 032051. https://doi.org/10.1088/1742-6596/1157/3/032051

Mukherjee, D. (2021). Food Security Under The Era Of Climate Change Threat. *Journal of Advanced Agriculture & Horticulture Research*, *1*(1), Article 1. https://doi.org/10.55124/jahr.v1i1.78

Nakai, K., & Tsuruta, D. (2021). What Are Reactive Oxygen Species, Free Radicals, and Oxidative Stress in Skin Diseases? *International Journal of Molecular Sciences*, *22*(19), Article 19. https://doi.org/10.3390/ijms221910799

Nickerson, J., Yen, C. J., & Mahoney, J. T. (2012). Exploring the Problem-Finding and Problem-Solving Approach for Designing Organizations. *Academy of Management Perspectives*, *26*(1), 52–72. https://doi.org/10.5465/amp.2011.0106

Okes, D. (2019). *Root Cause Analysis, Second Edition: The Core of Problem Solving and Corrective Action*. Quality Press.

Perdanasari, A., Sudiyanto, & Sangka, K. B. (2021). Development Needs Analysis of Teaching Materials for Improving Critical Thinking Skills Students in Century 21. *Journal of Physics: Conference Series*, *1808*(1), 012035. https://doi.org/10.1088/1742-6596/1808/1/012035

Rahman, M. M. (2019). *21st Century Skill "Problem Solving": Defining the Concept* (SSRN Scholarly Paper No. 3660729). Social Science Research Network. https://papers.ssrn.com/abstract=3660729

Ramakrishnan, P. (2022). Mastering the power of analytical thinking. In *Mastering the Power of You*. Routledge.

Salvi, A., Carrupt, P.-A., Tillement, J.-P., & Testa, B. (2001). Structural damage to proteins caused by free radicals: Asessment, protection by antioxidants, and influence of protein binding1. *Biochemical Pharmacology*, *61*(10), 1237–1242. https://doi.org/10.1016/S0006-2952(01)00607-4

Sasanti, W., Hemtasin, C., & Thongsuk, T. (2024). The Effectiveness of Inquiry-Based Learning to Improve the Analytical Thinking Skills of Sixth-Grade Elementary School Students. *Anatolian Journal of Education*, *9*(1), 37–56.

Singh, A., Mehta, S., Yadav, S., Nagar, G., Ghosh, R., Roy, A., Chakraborty, A., & Singh, I. K. (2022). How to Cope with the Challenges of Environmental Stresses in the Era of Global Climate Change: An Update on ROS Stave off in Plants. *International Journal of Molecular Sciences*, *23*(4), Article 4. https://doi.org/10.3390/ijms23041995

Tai, A. P. K., Martin, M. V., & Heald, C. L. (2014). Threat to future global food security from climate change and ozone air pollution. *Nature Climate Change*, *4*(9), 817–821. https://doi.org/10.1038/nclimate2317

Turpyn, J. M. F., & Adiwitya, A. (2021). Raising Awareness of Indonesiaâ€™s Climate Change Mitigation by Social Media Campaign. *Communicare : Journal of Communication Studies*, *8*(1), 51–61. https://doi.org/10.37535/101008120214

Ülker, D., Ergüven, O., & Gazioğlu, C. (2018). Socio-economic impacts in a Changing Climate: Case Study Syria. *International Journal of Environment and Geoinformatics*, *5*(1), Article 1. https://doi.org/10.30897/ijegeo.406273

Yayuk, E., Purwanto, As'ari, A. R., & Subanji. (2020). Primary School Students' Creative Thinking Skills in Mathematics Problem Solving. *European Journal of Educational Research*, *9*(3), 1281–1295.

Zhao, Q., Yu, P., Mahendran, R., Huang, W., Gao, Y., Yang, Z., Ye, T., Wen, B., Wu, Y., Li, S., & Guo, Y. (2022). Global climate change and human health: Pathways and possible solutions. *Eco-Environment & Health*, *1*(2), 53–62. https://doi.org/10.1016/j.eehl.2022.04.004