



Analysis of Grade 10 High School Students' Understanding of Renewable Energy Concepts Using the ANATES Application

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Abstract: The purpose of this study is to evaluate how high school grade X students understand the concepts of renewable energy using the ANATES tool. This study uses a descriptive quantitative approach with a sample of 60 students from two Grade X classes at SMAS Darul Falah Pagutan Mataram. The instrument used was in the form of 20 multiple-choice questions developed based on indicators of understanding renewable energy concepts. The test results were analyzed using ANATES to measure the level of conceptual understanding, the level of difficulty, and the discriminating power. The results showed that 25% of students were in the medium understanding category, 46.7% were in the very low category, and 28.3% were in the low category. Most of the questions were in the medium difficulty category (45%) and had varying discriminating power, with 50% classified as good, 5% as sufficient, and 45% as poor. This study recommends the need to improve learning strategies that emphasize an inquiry-based approach, the contextual integration of ESD (Education for Sustainable Development), and the use of evaluation tools that can provide informative feedback to enhance students' conceptual understanding of renewable energy.

Keywords: ANATES; Concept understanding; Renewable energy

Introduction

Global warming, climate change, and the energy crisis are the main challenges of the 21st century that require immediate educational responses. Reliance on fossil energy such as coal, petroleum, and natural gas has negatively impacted the environment through increased greenhouse gas emissions and pollution (IEA, 2022). In this context, renewable energy such as solar, wind, water, biomass, and geothermal power represents sustainable solutions because they come from ongoing natural processes, are more environmentally friendly, and have low carbon emissions (Chen et al., 2022; IRENA, 2023).

Education plays a crucial role in shaping awareness and understanding of the importance of transitioning to renewable energy. At the high school level, renewable

energy materials have been integrated into natural sciences learning to strengthen science literacy and environmental awareness, aligning with the Independent Curriculum's demands for learning relevance to real issues (Kemdikbud, 2022). However, research findings show that students' understanding of renewable energy concepts remains low, particularly in distinguishing energy sources, understanding energy efficiency, and explaining energy conversion processes (Suryawati & Osman, 2018; Johnson & Thompson, 2020; Davis, 2021; Kim et al., 2021; Wang et al., 2022; Smith et al., 2023).

This understanding gap potentially hinders the formation of environmentally friendly attitudes and behaviors that are goals of 21st-century education. Therefore, evaluation is needed that not only measures factual knowledge but also students' ability to apply

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concepts in real contexts using quality, valid, and reliable instruments (Nitko & Brookhart, 2019; Popham, 2020; Tessmer, 2020; Nieveen & Folmer, 2023; Akker et al., 2023). The ANATES application serves as a comprehensive tool to analyze question item quality while mapping students' conceptual understanding levels (Handayani & Nurohman, 2018; Miller & Brown, 2022). ANATES enables assessment of validity, reliability, difficulty level, discriminating power, and distractor effectiveness in multiple-choice questions (Sukardi, 2016; White & Green, 2021; Zhou & Anderson, 2022; Garcia et al., 2023).

The novelty of this research lies in applying ANATES not merely to measure evaluation instrument quality, but to comprehensively relate analysis results to students' renewable energy understanding profiles. This study provides empirical data on students' conceptual mastery while identifying specific misconceptions, offering data-driven input for teachers to improve evaluation instruments and develop more contextual, interactive science learning oriented toward environmental literacy.

Method

This study employs a descriptive quantitative approach aimed at describing the level of understanding of renewable energy concepts among grade X high school students based on test results analyzed using the ANATES version 4.0 application. This approach was chosen to obtain an objective picture of students' cognitive abilities and the quality of question items used.

The research population consists of all grade X students at SMA Darul Falah Pagutan Mataram who have received renewable energy materials in science subjects. The research sample was selected using purposive sampling, specifically students who have studied renewable energy materials and are willing to participate in the research test. The sample size was 60 students from two classes: X-A (30 students) and X-B (30 students).

The instrument used is a multiple-choice test of 20 questions developed according to renewable energy materials in the Independent Curriculum. Each question item has four answer options with one correct answer key. The measured materials include general knowledge of renewable energy (definition, types, and sources), understanding of energy conversion processes (efficiency, sustainability, and energy conservation), and application of renewable energy concepts in daily life.

Data collection was carried out in two stages: test implementation conducted for 60 minutes during science lesson hours, and data processing where students' answer sheets were analyzed using ANATES

to obtain the difficulty index, discriminating power, effectiveness of distractors, distribution of student scores, and statistical measures including the average, highest, and lowest values.

Data analysis was conducted through calculating student scores based on correct answers and converting scores to percentages to measure concept mastery levels. Student understanding levels were grouped into five categories according to the following criteria.

Table 1. Classification of conceptual understanding levels

Criteria	Value
Very high	(≥ 86)
High	(71-85)
Medium	(56-70)
Low	(41-55)
Very low	(≤ 40)

Results were interpreted through narrative descriptions, tables, and graphs. Question quality was analyzed based on ANATES output to assess whether question items are valid, reliable, and suitable for use in subsequent lessons.

Results and Discussion

Students' Concept Comprehension Level

The analysis results showed that out of 60 students, none achieved very high or high understanding levels of renewable energy concepts. The distribution of students' conceptual understanding is presented in Table 2.

Table 2. Students' conceptual understanding level distribution

Number of Students	Percentage (%)	Category
15	25	Medium
17	28.3	Low
28	46.7	Very Low

Based on data analysis results, 25% of students have medium-level understanding of renewable energy concepts, 28.3% are in the low category, and 46.7% are in the very low category. This shows that 75% of students do not achieve ideal understanding of renewable energy concepts. This condition indicates a gap between students' understanding and learning material mastery. Low conceptual understanding levels may be attributed to insufficient contextual and participatory learning approaches that encourage student involvement in actively constructing knowledge.

These results support findings by Setiawan & Rusdiana (2020) and Yang et al. (2023) that secondary school students still demonstrate poor understanding of renewable energy concepts. This necessitates changes to

learning methods emphasizing inquiry approaches, including ESD (Education for Sustainable Development) contexts, and using evaluation tools that provide useful feedback for conceptual improvement (UNESCO, 2021).

Question Item Analysis with ANATES

Analysis of 20 question items revealed varying difficulty levels distributed as shown in Table 3.

Table 3. Question difficulty level distribution

Number of Questions	Percentage (%)	Category
4	20	Easy
9	45	Medium
7	35	Difficult

Difficulty level analysis showed that 20% of questions were categorized as easy, 45% as medium, and 35% as difficult. Overall, this proportion shows good question distribution, with medium-difficulty questions being most appropriate for thoroughly evaluating students' understanding. A medium difficulty level provides the most representative information in evaluation processes as it can fairly assess both high-ability and low-ability students.

However, the 35% proportion of difficult questions indicates that the question structure requires further investigation. As stated by Arikunto (2012), Bloom et al. (2016), Azwar (2018), and Ebel & Frisbie (2019), overly difficult questions can cause student demotivation and provide insufficient information. Therefore, some difficult questions are suggested for revision to suit context, language, and cognitive level of grade X high school students.

Discriminating Power Analysis

Discriminating power analysis results are presented in Table 4.

Table 4. Question discriminating power distribution

Number of Questions	Percentage (%)	Category
10	50	Good
1	5	Sufficient
9	45	Poor

Discriminating power analysis showed that 50% of question items were classified as good, 5% as sufficient, and 45% as poor. These findings indicate that half of the question items effectively distinguish between students with high and low conceptual understanding. These questions are suitable for learning evaluation as they provide accurate pictures of students' ability variations.

However, the 45% proportion of questions with poor discriminating power represents a serious concern. These questions potentially reduce instrument validity as they cannot effectively distinguish student mastery

levels. Poor discriminating power can be caused by several factors including questions that are too easy or difficult, ambiguous answer choices, or lack of relevance to learning indicators. This aligns with Retnawati (2014) and Linn & Miller (2021) who argue that items with low discriminating power require substantial changes in wording, context, and distractor construction.

Discussion and Implications

The findings reveal significant challenges in students' renewable energy conceptual understanding, with most students (75%) falling below satisfactory comprehension levels. This situation demands immediate attention through improved pedagogical approaches and assessment strategies. The integration of inquiry-based learning methods, contextual ESD frameworks, and technology-enhanced evaluation tools represents crucial steps toward addressing these educational gaps.

The ANATES analysis demonstrates that while 50% of questions effectively discriminate between different ability levels, the substantial proportion (45%) of poorly discriminating items indicates systematic issues in assessment design. This finding emphasizes the importance of continuous instrument refinement and teacher professional development in constructing higher-order thinking skills (HOTS) questions.

Conclusion

This study reveals that most grade X high school students (75%) demonstrate inadequate understanding of renewable energy concepts, with 46.7% in the very low category, 28.3% in the low category, and only 25% achieving medium-level understanding. The ANATES analysis showed mixed instrument quality, with 50% of questions demonstrating good discriminating power while 45% require significant revision. Question difficulty distribution showed reasonable balance, though the 35% proportion of difficult items warrants careful review. These findings necessitate the implementation of more contextual and inquiry-based learning strategies emphasizing ESD integration to improve students' renewable energy conceptual understanding. Additionally, the systematic use of applications like ANATES can help teachers evaluate and improve evaluation instrument quality through data-driven approaches, ultimately supporting more effective science education aligned with 21st-century environmental literacy goals.

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

References

- Akker, J. V. D., Gravemeijer, K., McKenney, S., & Nieveen, N. (2023). *Educational Design Research*. London: Routledge.
- Arikunto, S. (2012). *Fundamentals of Educational Evaluation*. Jakarta: Bumi Aksara.
- Azwar, S. (2018). *Reliability and Validity*. Yogyakarta: Pustaka Pelajar.
- Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (2016). *Taxonomy of Educational Objectives: The Classification of Educational Goals*. Longmans, Green.
- Chen, X., Liu, Y., & Wang, Z. (2022). Renewable Energy Education in Secondary Schools: A Comparative Study Across Nations. *Journal of Cleaner Production*, 340, 130825. <https://doi.org/10.1016/j.jclepro.2022.130825>
- Davis, M. H. (2021). Assessment of Environmental Literacy in Science Education: Current Practices and Future Directions. *Environmental Education Research*, 27(8), 1145-1162. <https://doi.org/10.1080/13504622.2021.1921117>
- Ebel, R. L., & Frisbie, D. A. (2019). *Essentials of Educational Measurement*. Englewood Cliffs, NJ: Prentice-Hall.
- Garcia, L., Martinez, S., & Rodriguez, P. (2023). Digital Assessment Tools in Science Education: Effectiveness and Implementation Challenges. *Computers & Education*, 195, 104718. <https://doi.org/10.1016/j.compedu.2023.104718>
- Handayani, N., & Nurohman, S. (2018). Analysis of Multiple-Choice Questions for Science Subjects Using ANATES Software. *Journal of Science Education Innovation*, 4(1), 32-40. <https://doi.org/10.21831/jipi.v4i1.19352>
- IEA. (2022). *World Energy Outlook 2022*. International Energy Agency. Retrieved from <https://www.iea.org/reports/world-energy-outlook-2022>
- IRENA. (2023). *Renewable Energy: A Key Climate Solution*. International Renewable Energy Agency. Retrieved from <https://www.irena.org/publications>
- Johnson, K. L., & Thompson, R. M. (2020). Conceptual Understanding in Renewable Energy Education: A Systematic Review. *Renewable and Sustainable Energy Reviews*, 131, 110045. <https://doi.org/10.1016/j.rser.2020.110045>
- Kemdikbud. (2022). *Science Learning Outcomes Phase E – Independent Curriculum*. Jakarta: Ministry of Education, Culture, Research, and Technology.
- Kim, S., Park, J., & Lee, H. (2021). Effects of Inquiry-Based Learning on Environmental Awareness and Renewable Energy Understanding. *International Journal of Science Education*, 43(12), 1945-1965. <https://doi.org/10.1080/09500693.2021.1938670>
- Linn, R. L., & Miller, M. D. (2021). *Measurement and Assessment in Teaching*. Upper Saddle River, NJ: Merrill/Prentice Hall.
- Miller, A., & Brown, C. (2022). ANATES Application in Educational Assessment: A Comprehensive Review. *Assessment in Education*, 29(3), 245-261. <https://doi.org/10.1080/0969594X.2022.2076543>
- Nieveen, N., & Folmer, E. (2023). Formative Evaluation in Educational Design Research. *Design Research in Education*, 15(2), 152-169. <https://doi.org/10.1007/s10798-023-09812-1>
- Nitko, A. J., & Brookhart, S. M. (2019). *Educational Assessment of Students*. Boston: Allyn & Bacon.
- Popham, W. J. (2020). *Classroom Assessment: What Teachers Need to Know*. Boston: Allyn & Bacon.
- Retnawati, H. (2014). *Test and Measurement Theory: A Guide to Question Item Analysis*. Yogyakarta: Parama Publishing.
- Setiawan, A., & Rusdiana, D. (2020). Students' Conceptions of Renewable Energy: A Systematic Review. *Indonesian Journal of Science Education*, 9(1), 1-9. <https://doi.org/10.15294/jpii.v9i1.21204>
- Smith, J., Wilson, K., & Davis, L. (2023). Environmental Education and Sustainable Development: Current Trends and Future Directions. *Environmental Education Research*, 29(4), 512-530. <https://doi.org/10.1080/13504622.2023.2195847>
- Sukardi, S. (2016). *Educational Evaluation: Its Principles and Operations*. Jakarta: Bumi Aksara.
- Suryawati, E., & Osman, K. (2018). Contextual Learning to Improve Students' Understanding of Environmental Sustainability. *The Asia-Pacific Education Researcher*, 27(2), 147-156. <https://doi.org/10.1007/s40299-018-0379-2>
- Tessmer, M. (2020). *Planning and Conducting Formative Evaluations*. London: Kogan Page.
- UNESCO. (2021). *Education for Sustainable Development: A Roadmap*. United Nations Educational, Scientific and Cultural Organization. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000374802>
- Wang, L., Zhang, M., & Liu, X. (2022). Technology-Enhanced Assessment in Environmental Education:

- A Meta-Analysis. *Educational Technology Research and Development*, 70(3), 987-1008.
<https://doi.org/10.1007/s11423-022-10089-2>
- White, S., & Green, T. (2021). Assessment Validity in Science Education: Contemporary Perspectives and Practices. *Science Education*, 105(4), 678-702.
<https://doi.org/10.1002/sce.21652>
- Yang, H., Chen, R., & Wu, J. (2023). Renewable Energy Literacy Among Secondary School Students: A Cross-Cultural Study. *Energy Education Review*, 12(2), 89-105.
<https://doi.org/10.1016/j.eer.2023.02.045>
- Zhou, Y., & Anderson, P. (2022). Improving Assessment Quality Through Digital Tools: Evidence from Science Education. *Assessment & Evaluation in Higher Education*, 47(6), 856-871.
<https://doi.org/10.1080/02602938.2021.1987548>