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ANALYSIS OF STUDENTS' SCIENCE LITERACY ABILITY AT SIGI HIGH SCHOOL USING MIXED METHOD APPROACH: IMPLICATIONS OF CONCEPT UNDERSTANDING AND PROBLEM SOLVING IN DAILY LIFE

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ABSTRACT

This study analyzes the science literacy abilities of students at SMA Negeri 6 Sigi, focusing specifically on chemistry literacy. The objective is to evaluate the extent to which students understand chemistry concepts and can apply them in solving everyday problems. Using a mixed-method approach, qualitative data were collected through a Likert-scale questionnaire, while quantitative data were gathered from a multiple-choice test requiring reasoned responses. Results show that while students self-report high levels of chemistry understanding, their actual performance in applying these concepts is limited, with significant discrepancies observed between perceived and demonstrated abilities. The study highlights the importance of incorporating contextual and inquiry-based learning approaches in chemistry instruction to improve conceptual understanding and reasoning skills. These findings provide valuable insights for educators in enhancing chemistry literacy through real-life applications, ultimately fostering students' critical thinking and problem-solving skills.

Keywords: *science literacy, chemistry literacy, mixed-method, problem-solving, inquiry-based learning.*

INTRODUCTION

In the 21st century, scientific literacy has become an essential skill for navigating the increasingly complex issues that modern society faces. According to Nurdini et al. (2018), four primary domains characterize 21st-century capabilities: literacy, inventive thinking, efficient communication, and high productivity. Among these, scientific literacy stands out as it enables individuals to understand and critically evaluate information related to the environment, health, technology, and economy. These aspects are crucial in a society that increasingly relies on science and technology for progress and quality of life. Scientific literacy fosters informed decision-making and empowers individuals to engage meaningfully with societal challenges (Zandroto & Sinaga, 2022).

Science literacy in education prepares students to apply scientific concepts to real-life situations. Bagasta et al. (2018) define scientific literacy as the ability to utilize scientific knowledge, identify relevant questions, and draw evidence-based conclusions. This skill is essential for individuals to make decisions about nature and human interventions in it. However, recent studies indicate that science literacy levels among students in Indonesia remain low. TIMSS (Trends in International Mathematics and Science Study) data from 2015 ranked Indonesia 44th in scientific literacy, while the 2018 PISA (Programme for International Student Assessment) results placed Indonesia second to last among 79 countries, with an average science literacy score of 389 (Zandroto & Sinaga, 2022).

These results highlight significant gaps in Indonesia's education system, especially regarding students' ability to apply scientific knowledge to real-world issues. As a result, the 2013 Curriculum was introduced

to improve educational outcomes, focusing on science literacy as a means to equip students with critical thinking and problem-solving skills. However, implementing the 2013 Curriculum has not sufficiently addressed these challenges. Research by Fitriyani & Yulianti (2022) suggests that the current learning environment and methods used in schools have not fostered a strong foundation in scientific literacy among students. This issue is particularly evident in the field of chemistry, where students often find the subject difficult and disconnected from everyday life.

Chemistry literacy, a subset of scientific literacy, is vital for understanding complex environmental, health, and technological issues. According to Prasemmi et al. (2021), chemistry literacy involves the ability to interpret, evaluate, and communicate chemical information accurately. Students with strong chemistry literacy can make sense of scientific facts and apply this understanding in meaningful ways. However, students often struggle with chemistry concepts, viewing the subject as challenging and abstract. Sari et al. (2022) emphasize that improving chemistry literacy is essential for fostering an informed society that can navigate issues like pollution, energy use, and healthcare advancements.

Despite the need for improved science literacy, students in Indonesia face numerous challenges in developing these skills. The current research aims to investigate the science literacy abilities of students at Sigi High School, focusing on chemistry literacy. Through a mixed-method approach, combining both qualitative and quantitative assessments, this study will explore students' ability to understand, apply, and reason through chemistry-related problems. By examining students' proficiency in context, knowledge, attitude, and competency, this research aims to provide a comprehensive understanding of the literacy challenges they face.

The significance of this study lies in its implications for teaching practices and curriculum design. Identifying specific areas where students struggle in chemistry can inform instructional strategies that bridge the gap between theoretical concepts and practical applications. Teachers can use the findings to introduce chemistry topics through real-world contexts, enhancing student engagement and comprehension. The study's mixed-method approach enables a holistic view of students' literacy skills, providing insights into both their self-perceived understanding (qualitative data) and their actual performance on objective assessments (quantitative data).

In summary, this research seeks to evaluate the science literacy of students at Sigi High School, particularly in chemistry, and to identify areas for improvement. Given the demands of the 21st century, where scientific literacy is indispensable, this study contributes valuable insights into how education can better equip students with the skills needed for informed decision-making and problem-solving. By fostering a stronger foundation in science literacy, particularly chemistry, education can empower students to understand and engage with the scientific and technological changes shaping society.

LITERATURE REVIEW

Scientific Literacy in Education

Scientific literacy is recognized as a foundational skill that enables individuals to understand and critically assess scientific information in everyday contexts. According to Bagasta et al. (2018), scientific literacy involves utilizing scientific knowledge,

identifying relevant questions, and drawing evidence-based conclusions to understand natural phenomena and human interventions. Scientific literacy, therefore, goes beyond mere knowledge acquisition; it also entails the ability to apply knowledge practically and ethically. This competency is crucial in a rapidly advancing world, where individuals need to make informed decisions about health, environment, and technology.

Global assessments, such as the TIMSS and PISA, consistently highlight Indonesia's low performance in scientific literacy, pointing to significant challenges within the country's educational system. The 2018 PISA assessment, for example, ranked Indonesia near the bottom of 79 countries, with a science literacy score of 389 (Zandroto & Sinaga, 2022). These findings suggest that Indonesia's educational strategies may require reevaluation, particularly in cultivating scientific literacy in ways that resonate with students' real-life experiences. The 2013 Curriculum was introduced to address these issues, aiming to foster critical thinking and problem-solving. However, studies by Fitriyani & Yulianti (2022) indicate that the curriculum's impact has been limited due to inadequate implementation and lack of contextual learning.

Chemistry Literacy as a Component of Scientific Literacy

Chemistry literacy is an integral component of scientific literacy, focusing on understanding chemical principles and applying them to solve everyday problems. Prasemmi et al. (2021) define chemistry literacy as the ability to evaluate, interpret, and communicate chemical information accurately, which is essential for addressing complex issues related to health, environment, and technology. Chemistry literacy enables individuals to understand the properties and behaviors of substances, how they interact, and the implications for personal and societal well-being.

In Indonesian high schools, chemistry is often perceived as challenging and abstract, with many students struggling to see its relevance to daily life. Research by Sari et al. (2022) highlights that students frequently view chemistry concepts as difficult, contributing to low engagement and understanding. This problem is further compounded by the traditional teaching methods commonly employed, which tend to focus on rote memorization of formulas and reactions without meaningful connections to real-world applications. Studies show that students who struggle with chemistry literacy are less likely to engage actively in the learning process and may have limited ability to apply scientific principles to problem-solving in daily life (Permatasari & Fitriza, 2019).

Challenges in Developing Scientific and Chemistry Literacy

Developing scientific literacy in Indonesia is hindered by several educational challenges. According to Nurdini et al. (2018), these include curriculum limitations, teacher readiness, and a lack of practical learning resources that emphasize science literacy. The PISA and TIMSS findings underscore that Indonesian students often struggle with scientific concepts that require analytical and critical thinking skills. The traditional approach of teaching science and chemistry as isolated theoretical subjects limits students' ability to connect these subjects with daily life (Fitriyani & Yulianti, 2022).

Chemistry literacy, in particular, demands an understanding of abstract concepts that can be challenging to convey through traditional lecture-based teaching methods. Zandroto & Sinaga (2022) argue that chemistry lessons in Indonesia often lack contextualization, making it difficult for students to grasp the significance of chemical knowledge in real-world scenarios. Furthermore, students are rarely encouraged to engage in inquiry-based learning activities that foster critical thinking, such as conducting experiments, analyzing data, or exploring real-life applications. This limitation not only hampers students' scientific literacy but also restricts their ability to solve practical problems related to science and technology.

The Role of Mixed-Method Research in Assessing Scientific Literacy

Mixed-method research, which combines both quantitative and qualitative approaches, has become an effective tool for evaluating complex educational competencies like scientific literacy. Mixed-method approaches allow for a more comprehensive understanding of students' literacy abilities by capturing both numerical data on performance and insights into attitudes and perceptions. Research by Bagasta et al. (2018) supports the value of mixed methods in assessing science literacy, as qualitative data reveal students' personal experiences, attitudes, and thought processes, while quantitative data provide measurable indicators of literacy levels.

In the context of chemistry literacy, mixed-method approaches enable educators to assess students' knowledge, conceptual understanding, and practical application skills. A Likert-scale questionnaire, for example, can measure students' self-reported knowledge and attitudes toward chemistry, while a multiple-choice reasoning test can objectively assess their ability to apply chemistry concepts. By integrating both forms of data, mixed-method research offers a nuanced understanding of students' strengths and areas for improvement, guiding educators in developing targeted instructional strategies (Nurdini et al., 2018).

Implications of Chemistry Literacy on Problem-Solving and Decision-Making

Chemistry literacy is crucial not only for academic success but also for personal decision-making and problem-solving in daily life. According to Prasemmi et al. (2021), individuals with high chemistry literacy can better understand issues related to health, environmental protection, and technology. For example, they may be able to interpret chemical labels, make informed choices about household products, or understand the implications of pollution and waste management.

In the classroom, fostering chemistry literacy through problem-based learning and real-life applications can enhance students' critical thinking skills. Permatasari & Fitriza (2019) emphasize the importance of involving students in learning activities that mirror real-life scenarios, such as analyzing environmental issues, understanding chemical processes in the body, or exploring sustainable practices. Such activities not only enhance chemistry literacy but also equip students with the skills needed to navigate and respond to the challenges of the 21st century.

The existing literature underscores the critical role of scientific and chemistry literacy in preparing students for a scientifically literate society. Despite the implementation of the 2013 Curriculum aimed at fostering these skills, challenges in Indonesia's education system have limited

progress. Traditional teaching methods and a lack of practical applications in chemistry education contribute to low literacy levels, impeding students' ability to apply scientific knowledge in real-world contexts. Mixed-method research offers valuable insights into students' understanding and perceptions of chemistry, providing a basis for developing strategies that make learning more relevant and engaging. The insights gained from this literature review will inform the present study's approach to assessing the science literacy abilities of students at Sigi High School, focusing on the practical implications of chemistry literacy for concept understanding and problem-solving.

METHOD

This study employs a mixed-method research design combining qualitative and quantitative approaches to provide a comprehensive analysis of students' science literacy abilities, specifically in chemistry, at Sigi High School. The mixed-method approach enables the research to capture both the measurable aspects of chemistry literacy and the subjective experiences, attitudes, and perceptions of students.

Participants

The study sample consisted of 98 students from the XII MIPA class at SMA Negeri 6 Sigi during the 2023/2024 academic year. The participants were selected as they represent students nearing the completion of secondary education, making them ideal for assessing science literacy levels in preparation for real-world applications. These students were from a science-oriented program, which typically includes a greater emphasis on chemistry and scientific literacy.

Data Collection Instruments

To assess chemistry literacy, the study utilized two main instruments:

a) Likert-Scale Questionnaire: This questionnaire was designed to gather qualitative data on students' self-perceived understanding, attitudes, and engagement with chemistry. It comprised 18 items based on general chemistry concepts and real-life applications, rated on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree." The questionnaire assessed four primary aspects:

1) Context: Students' perceived relevance of chemistry in real-world contexts.
2) Knowledge: Self-reported understanding of chemistry concepts.
3) Attitude: Interest and motivation towards learning chemistry.
4) Competence: Confidence in using chemistry knowledge to solve problems.

b. Multiple-Choice Reasoned Test: A multiple-choice test with 11 reasoned questions was developed to quantitatively measure students' chemistry literacy. Each question required students to choose an answer and provide a reason, assessing their ability to apply chemistry knowledge in solving practical problems. The test covered foundational chemistry topics, including chemical reactions, element properties, and daily-life applications of chemistry. The reasoning aspect was crucial, as it indicated students' depth of understanding and ability to justify their answers logically.

Data Collection Procedure

Data collection was conducted over two sessions in a classroom setting at SMA Negeri 6 Sigi:

a) Session 1: Questionnaire Administration: The Likert-scale questionnaire was administered first, allowing students to reflect on their chemistry literacy and attitudes. Instructions emphasized the importance of honest responses to ensure accuracy in qualitative assessment.
b) Session 2: Multiple-Choice Reasoned Test: In the subsequent session, students completed the multiple-choice test individually. They were encouraged to provide detailed reasoning for each answer, which was later analyzed to assess their conceptual understanding and ability to apply knowledge in practical situations.

Additionally, classroom observations and documentation were conducted to provide context and support the findings. Observations included students' interactions with the instruments and responses to questions posed during the sessions, recorded through notes and photos for further analysis.

Data Analysis

The study used distinct methods for analyzing qualitative and quantitative data:

1) Qualitative Analysis: Responses from the Likert-scale questionnaire were analyzed using descriptive statistics to categorize students' perceptions across the four aspects (context, knowledge, attitude, competence). The average scores for each item were calculated and categorized as "Very Poor," "Poor," "Fair," "Good," or "Excellent" based on the scoring scale.
2) Quantitative Analysis: Data from the multiple-choice reasoned test were analyzed to calculate the overall accuracy and reasoning quality. Each correct answer received one point, with additional points for justified, coherent reasoning. The test results were then categorized as "Very Poor," "Poor," "Fair," "Good," or "Excellent" based on the percentage of correct answers. The average percentage score was calculated, and ANOVA tests were conducted to determine any significant differences in scores across the four literacy aspects.

Validity and Reliability

To ensure the validity and reliability of the instruments:

a) Content Validity: Both instruments were reviewed by chemistry education experts to ensure they accurately measured chemistry literacy as defined by the theoretical framework. Adjustments were made based on feedback to improve question clarity and relevance.
b) Pilot Testing: A pilot test of both the questionnaire and multiple-choice test was conducted with a small sample of students not involved in the main study. This helped identify any ambiguities in the questions and ensured that the test instructions were clear.
c) Reliability Testing: The internal consistency of the Likert-scale questionnaire was measured using Cronbach's Alpha, with a target reliability coefficient of at least 0.70 to confirm reliability. The multiple-choice test's reliability was assessed using the test-retest method, comparing scores from the pilot and main study to check for consistency in results.

RESULT AND DISCUSSION

This study analyzed students' chemistry literacy at Sigi High School using a mixed-method approach, which provided

insights into their self-perceived understanding (qualitative data) and their demonstrated ability to apply chemistry knowledge in problem-solving (quantitative data). The results reveal key discrepancies between students' perceptions of their chemistry abilities and their actual performance on conceptual and reasoning-based assessments.

Results from the Likert-Scale Questionnaire

The Likert-scale questionnaire assessed four aspects: context, knowledge, attitude, and competence. The findings are as follows:

a) Context: Approximately 45% of students rated their ability to relate chemistry to real-world contexts as "Good," indicating a perceived awareness of the subject's relevance. However, only 25% rated this aspect as "Excellent," suggesting that a significant portion of students may lack confidence in fully contextualizing chemistry in daily life.
b) Knowledge: In terms of self-reported knowledge, 58% of students placed themselves in the "Good" category. This result indicates that the majority of students feel they have a satisfactory understanding of basic chemistry concepts. However, only 15% rated their knowledge as "Excellent," which may reflect limited depth in understanding more complex topics.
c) Attitude: The students' attitudes toward chemistry were generally positive, with 51% rating this aspect as "Good." Many expressed enthusiasm for learning chemistry, although there remains a group (around 10%) who view chemistry as challenging and less engaging.
d) Competence: About 48% of students rated their competence in using chemistry knowledge to solve problems as "Good." Nevertheless, the lower percentage of students with "Excellent" ratings (12%) suggests that while students feel competent, many still lack confidence in applying their knowledge effectively.

Overall, the qualitative data from the Likert-scale questionnaire indicates that students perceive themselves as having a reasonable understanding of chemistry concepts and a positive attitude towards the subject. However, there remains room for improvement in confidence and depth of knowledge.

Results from the Multiple-Choice Reasoned Test

The quantitative results from the multiple-choice reasoned test revealed a different profile of students' chemistry literacy:

a) Contextual Application: Only 15% of students answered questions related to real-world applications of chemistry correctly, and of these, only 5% provided coherent reasoning. This aspect was categorized as "Very Poor," indicating that while students recognize the relevance of chemistry, they struggle to apply this knowledge practically.
b) Knowledge: Only 30% of students answered conceptual questions correctly, and fewer than 10% could provide accurate reasoning for their choices. This aspect was categorized as "Poor," highlighting a gap between students' perceived and actual understanding of fundamental concepts.
c) Attitude towards Problem-Solving: Although many students expressed

positive attitudes in the questionnaire, the test results showed that they found it challenging to apply these attitudes effectively in problem-solving. The average score for this aspect was "Very Poor," with fewer than 20% of students providing correct answers and justifications.

d) Competence in Reasoning: Only 10% of students demonstrated satisfactory reasoning skills on complex questions, resulting in an overall "Very Poor" rating for this aspect. Students often failed to provide logical explanations for their answers, suggesting a limited ability to engage in scientific reasoning.

The quantitative data demonstrates a considerable discrepancy between students' self-assessed abilities and their actual performance on chemistry-related problems. While students may feel competent and interested in chemistry, the results suggest that their understanding is largely superficial and lacks the depth needed for effective application.

The findings from this study highlight several key insights into students' chemistry literacy at Sigi High School and offer implications for educational practice:

Discrepancies between Perception and Reality

The contrast between the qualitative and quantitative data suggests that students overestimate their chemistry literacy. Many students believe they understand chemistry concepts well, but their reasoning abilities reveal significant gaps. This discrepancy may stem from a lack of exposure to problem-based learning, where students are required to apply their knowledge critically. Encouraging teachers to incorporate more practical applications and problem-solving activities could bridge the gap between perceived and actual competence.

Implications of Attitude on Learning Outcomes

The positive attitudes expressed by many students toward chemistry are encouraging, as they indicate a willingness to engage with the subject. However, without a solid understanding of concepts, this positive attitude alone does not translate into high performance. Research indicates that a favorable attitude towards science, when combined with hands-on, inquiry-based learning, can lead to improved understanding and retention of scientific concepts (Nurdini et al., 2018). Teachers could leverage students' interest by integrating real-life examples that highlight chemistry's relevance, thereby reinforcing positive attitudes through deeper engagement with the material.

Challenges in Developing Scientific Reasoning

The results underscore the difficulty students face in applying scientific reasoning to complex chemistry problems. Students' limited competence in this area suggests that traditional teaching methods, which often emphasize rote memorization and formulaic problem-solving, may hinder their ability to think critically. Developing scientific reasoning requires active engagement in hypothesis formulation, experimentation, and critical analysis (Zandroto & Sinaga, 2022). Introducing inquiry-based activities and guided reasoning exercises in the classroom could help students improve their scientific reasoning skills.

Need for Contextual Learning Approaches

Students' struggles with contextual applications indicate that they lack

opportunities to connect chemistry concepts with real-world scenarios. Contextual learning, which frames science education within relevant and meaningful contexts, has been shown to enhance students' understanding and application of science concepts (Permatasari & Fitriza, 2019). Incorporating contextual learning approaches, such as case studies, simulations, and fieldwork, could foster students' ability to apply their chemistry knowledge in practical settings.

Implications for Curriculum and Instructional Design

The results suggest a need for curriculum and instructional modifications to support chemistry literacy. Given the significant discrepancies between students' self-perceptions and actual capabilities, educators should focus on developing diagnostic assessments that accurately measure students' understanding and reasoning abilities. Instructional strategies that emphasize inquiry-based learning, real-life applications, and problem-solving could address the observed gaps in knowledge and reasoning.

CONCLUSION

This study provides a comprehensive analysis of students' chemistry literacy at Sigi High School, utilizing a mixed-method approach to examine both their self-perceived understanding and their actual performance in chemistry-related problem-solving. The findings reveal a significant discrepancy between students' perceptions of their abilities and their demonstrated competence in applying chemistry concepts to real-world situations. While many students express confidence in their chemistry knowledge and hold positive attitudes toward the subject, the quantitative assessments indicate limited depth in their understanding and reasoning abilities.

The results indicate that students may struggle with conceptual application and reasoning due to traditional instructional approaches that emphasize rote memorization rather than contextual and inquiry-based learning. Without sufficient opportunities to connect chemistry with real-life applications, students may perceive the subject as abstract and challenging. This lack of contextual understanding hinders their ability to utilize scientific concepts in practical situations, reflecting a gap that must be addressed to enhance chemistry literacy and scientific reasoning.

The study's findings have important implications for curriculum design and instructional strategies. To bridge the gap between perceived knowledge and actual competence, educators should consider integrating problem-based learning, real-world applications, and inquiry-based activities into their teaching practices. By providing students with more opportunities to engage critically with chemistry concepts and explore their relevance in daily life, educators can foster a deeper understanding and improve students' readiness for real-world challenges. Additionally, diagnostic assessments that accurately measure both conceptual understanding and reasoning abilities can help identify specific areas where students need support.

In conclusion, enhancing chemistry literacy requires a shift from traditional teaching methods toward approaches that actively involve students in applying knowledge and developing scientific reasoning. By equipping students with the

skills to understand, evaluate, and solve chemistry-related problems, education can play a pivotal role in preparing scientifically literate individuals capable of making informed decisions and contributing meaningfully to society. Future research could further explore the effectiveness of specific instructional strategies, such as contextual learning and inquiry-based approaches, in improving chemistry literacy. Addressing these educational needs is crucial for empowering students with the competencies required for the demands of the 21st century.

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