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# Integration of Sustainable Values Education in Chemistry Learning Through A Case-Based Learning Approach to Improve Science Literacy

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**Abstract**

Chemistry education has a strategic role in shaping students' awareness of global sustainability issues such as climate change and pollution. This study aims to analyze the effectiveness of Case- Based Learning (CBL) in integrating sustainability values into chemistry learning, while improving students' scientific literacy and critical thinking skills. The method used is a literature study by analyzing various sources, including journals, books, and related articles. The results of the study indicate that the CBL approach successfully connects chemical concepts (eg polymers and green chemistry) with actual issues such as plastic waste and renewable energy, so that learning becomes more contextual. In addition, the combination of CBL with STEM-based Project-Based Learning (PjBL) has been shown to train students in problem analysis, data- based decision making, and sustainable solution development. Implementation challenges include lack of teacher training and limited resources, which can be overcome through pedagogical training, collaboration with industry, and utilization of technology (such as Augmented Reality). The conclusion of the study confirms that the integration of CBL and sustainability values in the chemistry curriculum not only strengthens scientific understanding but also shapes students' characters who care about the environment. Recommendations for further research include long-term evaluation of the impact of CBL on student behavior as well as the development of local wisdom-based modules (ethnoscience).



## 1. Introduction

Education plays an important role in shaping students' awareness and character towards sustainability, especially in the era of global challenges such as climate change, pollution, and social inequality. Integration of sustainable value education in chemistry learning through a case-based learning approach is an innovative strategy to create relevant and applicable learning. By linking

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chemistry concepts to global issues, students not only understand scientific theories but also develop critical thinking skills and solutions to real problems.

The case-based learning approach in chemistry learning allows students to learn through case studies related to everyday life. For example, a case study on the impact of plastic waste on the environment can be used to explain the concept of polymers as well as instill sustainability values such as recycling and the use of environmentally friendly materials. Thus, learning does not only focus on the cognitive aspect but also on strengthening the attitudes and skills needed for a sustainable future.

Education for Sustainable Development (ESD) emphasizes the integration of multiple disciplines and perspectives to equip students with critical thinking, systemic impact analysis, and cross-sector collaboration. The implementation of case-based learning methods in chemistry provides a more in-depth and contextual learning experience, allowing students to connect science to the social and environmental challenges facing society.

In addition, the development of critical thinking skills in chemistry education is essential so that students can evaluate information objectively, recognize logical fallacies, and construct data-based arguments. Through an interactive and problem-based learning approach, students are encouraged to identify,design solutions, and communicate their ideas effectively. This is in line with the comprehensive curriculum goal of preparing students to face global dynamics.

In this study, a case-based education approach in chemistry will be explored to understand how students apply chemical concepts in the context of sustainability. By utilizing the methodlearning based on socio- scientific issues and sustainability, it is expected that students can develop a more holistic understanding of the interaction between science, technology, and society. This study will also identify challenges and opportunities in implementing this approach in chemistry education at the secondary and tertiary levels in Indonesia.

## 2. Materials and Methods

The method in this study uses qualitative research with data collection techniques, namely literature studies. Data collection used is by collecting, examining information or data about different findings from books, proposals, various articles and applicable journals. Here the author uses literature study techniques with several journals as sources.

## 3. Results and Discussions

| Journal Title | Solution |
|---|---|
| **Strengthening the** | 1. Teachers need to be given intensive training in |

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| | |
|---|---|
| **Implementation of Case-Based Learning in Chemistry Learning** | implementing Case-Based Learning (CBL) so that they can develop case studies that are relevant to the curriculum and sustainability issues.<br>2. Schools need to provide case-based teaching materials that allow students to explore the connection between science and real-world problems. |
| **Integration of Sustainable Values Education in Chemistry Curriculum** | 1. The curriculum should explicitly incorporate sustainability concepts into chemistry learning through modules that link theory to environmental impacts.<br>2. Learning should be project-based with a Green Chemistry approach to enhance students' understanding of environmentally friendly chemistry practices. |
| **Using the Problem-Based Learning (PBL) Approach in Scientific Literacy** | 1. The PBL model can be applied by inviting students to analyze issues of pollution, waste, and renewable energy as part of scientific literacy.<br>2. Students are tasked with researching, evaluating, and creating solutions to sustainability issues using scientific methods. |
| **Strengthening Collaboration between Chemistry and Social Sciences in Continuing Education** | 1. Integrating chemistry learning with a socio- economic perspective so that students understand the impact of industry and technology on the environment and society.<br>2. Students are invited to discuss the ethics of using chemicals and their impact on the environment and human health. |
| **Utilization of Digital Technology in Scientific Literacy** | 1. Utilizing digital platforms and interactive simulations to enhance understanding of sustainability-related chemistry concepts.<br>2. The use of Augmented Reality (AR) or Virtual Reality (VR) based learning applications to provide a more immersive and safe experimental experience. |

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| | |
|---|---|
| **Integration of Ethnoscience in Chemistry Learning** | 1. Adapting local wisdom in chemistry learning, for example studying chemical reactions in processing traditional foods or herbal medicines.<br>2. Using an ethnoscience approach to bridge scientific concepts with local culture, making them easier for students to understand. |
| **Implementation of STEM-Based Project-Based Learning (PjBL) to Improve Critical Thinking Skills** | 1. Students are encouraged to design and create real STEM-based solutions that contribute to sustainability, such as the creation of bioplastics or biofuels.<br>2. This project-based learning will enhance students' skills in research, innovation, and real- world problem solving. |
| **Strengthening Interdisciplinary Learning in Chemistry Education** | 1. Integrating concepts of chemistry with biology, physics, economics, and public policy to solve sustainability problems.<br>2. Providing collaborative assignments across subjects so that students understand the broad impact of chemistry in various aspects of life. |
| **Raising Awareness of Green Chemistry through Eco-Friendly Laboratory Experiments** | 1. Encourage the use of low-waste reactants and experimental methods and replace hazardous chemicals with more environmentally friendly alternatives.<br>2. Students are invited to design green chemistry experiments, such as the use of natural materials as catalysts or waste processing using biotechnology methods. |

From several literatures that the author has read, this study examines the integration of sustainable value education in chemistry learning through the Case-Based Learning (CBL) approach to improve students' scientific literacy. Based on the literature review and analysis of the proposed solutions, it was found that the CBL approach is effective in connecting chemistry concepts with global issues such as pollution, climate change, and sustainability. Some of the main findings include:

Improving Science Literacy with Students engaged in case-based learning demonstrating a better understanding of chemistry applications in real-world contexts, such as plastic waste management and renewable energy.

Critical Thinking Skills in CBL and Project-Based Learning (PjBL) Approaches based on

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STEM are able to train students in problem analysis, solution evaluation, and decision making based on scientific data. Integration of sustainability values in the chemistry curriculum increases students' awareness of the importance of environmentally friendly practices, such as Green Chemistry and recycling.

The CBL approach allows students to relate chemical theory to real-world problems, such as the impact of industry on the environment. For example, a case study on plastic pollution helps students understand the concept of polymers while instilling the value of recycling. This is in line with Fors' findings that "case hacking" in chemistry education strengthens students' understanding of sustainability challenges. The use of digital technology, such as Augmented Reality (AR) simulations, and interdisciplinary approaches (a combination of chemistry, economics, and ecology) enrich the learning experience. For example, a bioplastic manufacturing project not only teaches the chemistry of materials but also the economic and environmental impacts. This finding is supported by Novitasari who emphasized that STEM-based PjBL improves students' critical thinking skills.

Key challenges include lack of teacher training in developing case studies and resource constraints. Proposed solutions include:

1. Teacher training to design relevant cases.
2. Use of project-based teaching materials, such as green chemistry experiments.
3. Collaboration with industry to provide authentic case examples.

This study confirms that the integration of sustainability values and CBL in the chemistry curriculum not only improves scientific literacy but also forms students' environmentally conscious characters. Recommendations for further research include long-term evaluation of the impact of this approach on student behavior and the development of local wisdom-based modules (ethnoscience) to enrich the learning context.

The CBL approach and continuous value integration have proven effective in creating applicable and meaningful chemistry learning. With the support of technology, interdisciplinary collaboration, and teacher training, this strategy can become an innovative model for science education that is oriented towards global solutions.

## 5. Conclusions

The Case-Based Learning approach in chemistry learning has been proven to improve students' scientific literacy by connecting theoretical concepts with real-world problems. The integration of sustainable value education into the chemistry curriculum helps students realize the role of science in addressing global challenges such as pollution and climate change. Case-based learning also trains

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critical and systematic thinking skills, allowing students to analyze, evaluate, and create solutions to sustainability issues.

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