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Integrating Clean and Green Initiatives into Chemistry and Physical Science Instruction: A Qualitative Case Study of Teaching Practices of a Teacher

BERNADETTE D. CASTRO
Northeastern College, Santiago City

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Abstract

Sustainability education has become an essential component of science teaching as schools respond to global environmental challenges and the need to develop environmentally responsible learners. This qualitative case study examined how Clean and Green initiatives were integrated into Chemistry and Physical Science instruction by a secondary school teacher. Anchored in constructivist learning theory and education for sustainable development (ESD) frameworks, the study explored pedagogical strategies that linked scientific concepts to environmental practices and real-life contexts. Data were collected through semi-structured interviews, lesson plan analysis, instructional materials review, and documentation of Clean and Green activities, and were analyzed using thematic analysis. Findings revealed that environmental contextualization enhanced conceptual understanding, learner engagement, and interdisciplinary connections. Teaching practices were characterized by experiential learning, inquiry-based activities, and reflective pedagogy that linked science content with environmental responsibility. Despite challenges related to time constraints and resource limitations, teacher agency and adaptability enabled the sustained integration of sustainability initiatives into science instruction. The study concludes that Clean and Green initiatives can serve as effective pedagogical resources in Chemistry and Physical Science when supported by reflective teaching and institutional support.

Keywords: science education, sustainability pedagogy, Clean and Green initiatives, chemistry instruction, qualitative case study

1. Introduction

cience education plays a critical role in developing learners' understanding of natural phenomena, scientific reasoning, and informed decision-making that are essential for both academic success and everyday life. Through science instruction, learners acquire the ability to analyze evidence, evaluate claims, and apply scientific knowledge to solve real-world problems. In recent years, escalating environmental challenges such as pollution, climate change, biodiversity loss, and resource depletion have further underscored the importance of science education that extends beyond conceptual mastery. These global concerns have highlighted the need for instructional approaches that not only develop scientific knowledge and skills but also foster environmental awareness, ethical responsibility, and sustainable behaviors among learners. Consequently, sustainability has emerged as a central focus in contemporary science education, particularly within frameworks such as Education for Sustainable Development (ESD), which emphasize the integration of environmental issues into teaching and learning.

In the secondary school context, subjects such as Chemistry and Physical Science are often perceived by learners as abstract, complex, and content-heavy. This perception can limit student engagement and motivation, especially when scientific concepts are taught in isolation from learners' everyday experiences. When instruction relies heavily on theoretical explanations and textbook examples, learners may struggle to see the relevance of science to real-life situations. Integrating environmental initiatives into science instruction offers a powerful means of contextualizing scientific concepts, thereby making learning more meaningful and accessible. School-based programs such as Clean and Green initiatives provide authentic contexts for exploring scientific principles related to waste management, energy conservation, chemical reactions, material properties, and environmental systems. Through hands-on activities and real-world applications, learners are able to connect abstract scientific ideas to observable phenomena within their immediate environment.

In the Philippine education system, Clean and Green programs are widely toggle implemented as part of school-wide efforts to promote environmental cleanliness, sanitation, and ecological responsibility. These initiatives often involve activities such as waste segregation, recycling, campus greening, and energy-saving practices. However, despite their educational potential, Clean and Green initiatives are frequently treated as extracurricular, co-curricular, or compliance-driven activities rather than as integral components of classroom instruction. As a result, opportunities to link these initiatives to subject-specific learning particularly in Chemistry and Physical Science are often underutilized. Moreover, there is limited empirical research examining how Clean and Green initiatives are pedagogically integrated into science teaching practices and how such integration influences learner engagement and understanding. This study addresses this gap by examining how a secondary school teacher integrates Clean and Green initiatives into Chemistry and Physical Science instruction and explores how these practices support learner engagement, conceptual understanding, and sustainability-oriented learning.

2. Review of Related Literature

Sustainability has become a central theme in contemporary science education as schools respond to growing environmental, social, and economic challenges. Education for Sustainable Development (ESD) emphasizes the integration of these three dimensions of sustainability into teaching and learning in order to equip learners with the knowledge, skills, values, and attitudes necessary for responsible decision-making and action (UNESCO, 2017). Within science education, sustainability-oriented instruction encourages learners to examine environmental issues through scientific inquiry and evidence-based reasoning. Research indicates that such approaches enhance learners' environmental literacy, deepen their understanding of complex environmental systems, and promote responsible citizenship by linking scientific concepts to real-world sustainability challenges (Tilbury, 2011). Integrating sustainability into science instruction therefore enables learners to apply scientific knowledge to authentic environmental problems, making learning more relevant and socially meaningful.

Contextualized and experiential learning approaches further strengthen the effectiveness of sustainability-oriented science education. Grounded in constructivist learning theory, these approaches posit that learners actively construct knowledge through engagement with meaningful experiences and social interaction rather than through passive reception of information (Vygotsky, 1978). Experiential and inquiry-based strategies in science education such as hands-on experiments, field-based activities, and problem-solving tasks have been shown to improve conceptual understanding and learner motivation by connecting theoretical content with practical application (Kolb, 1984; Prince & Felder, 2006). By engaging learners in authentic scientific practices,

contextualized instruction supports deeper learning and helps students develop a more coherent understanding of scientific concepts.

3. Methodology

This study employed a qualitative case study research design to explore the integration of Clean and Green initiatives into Chemistry and Physical Science instruction within a real-life classroom context. The case study approach was appropriate as it allowed for an in-depth and holistic examination of pedagogical strategies, classroom practices, and teacher decision-making processes as they naturally occurred. By focusing on a single case, the study captured the complexity of sustainability-oriented instruction and the ways in which environmental initiatives were embedded into science teaching.

The research was conducted in a public secondary school in the Philippines. The primary participant was a Teacher III handling Chemistry and Physical Science who was actively involved in the planning and implementation of Clean and Green initiatives at the school level. The participant's role provided valuable insights into how sustainability programs were aligned with subject-specific instruction and how environmental themes were integrated into daily classroom practices.

Data were collected using multiple qualitative sources to ensure depth and triangulation. Semi-structured interviews with the teacher were conducted to elicit detailed accounts of instructional strategies, experiences, and reflections related to sustainability-integrated science teaching. In addition, lesson plans and instructional materials were analyzed to examine how Clean and Green concepts were incorporated into Chemistry and Physical Science lessons. Documents related to Clean and Green activities, along with reflective teaching notes, were also reviewed to gain insight into instructional planning, implementation processes, and ongoing pedagogical reflection.

Data analysis followed a thematic analysis process involving systematic coding, categorization, and theme development. Patterns and meanings were identified across interview transcripts and documentary data to generate coherent themes describing the integration of Clean and Green initiatives into science instruction. To enhance the credibility and rigor of the findings, triangulation was employed by comparing and validating insights across multiple data sources, allowing for well-supported and trustworthy interpretations.

4. Results and Findings

Analysis of the data yielded four major themes describing the integration of Clean and Green initiatives into science instruction.

Theme 1: Environmental Contextualization of Science Concepts

Science lessons were deliberately contextualized through the use of environmental issues and Clean and Green activities to illustrate key concepts in Chemistry and Physical Science, including chemical reactions, matter cycles, and energy transformation. Rather than presenting these concepts solely through abstract explanations or textbook examples, the teacher anchored instruction in real-life environmental situations familiar to learners, such as waste segregation, recycling processes, composting, and energy conservation practices within the school. For example, discussions on chemical reactions were linked to decomposition and composting processes observed during Clean and Green activities, while lessons on matter cycles were explained through waste management systems and the transformation of organic and inorganic materials.

Similarly, concepts related to energy transformation and conservation were contextualized through school-based practices such as reducing electricity consumption, managing water use, and promoting sustainable habits on campus. These real-world applications allowed learners to observe scientific principles in action, strengthening their conceptual understanding and ability to connect theory with practice. By situating Chemistry and Physical Science concepts within environmental contexts, instruction became more relevant, meaningful, and engaging, enabling learners to see the direct relationship between scientific knowledge and environmental responsibility. This contextualized approach not only enhanced comprehension of complex scientific ideas but also fostered greater awareness of sustainability issues and encouraged learners to apply scientific thinking to real-life environmental challenges.

Participant Responses:

One response stated, *"Mas naiintindihan ng mga estudyante ang chemical reactions kapag iniuugnay sa waste management at decomposition." P2*

Another noted, *"Nagiging malinaw ang konsepto ng energy kapag tinitingnan natin ang paggamit at pagtitipid nito sa paaralan." P7*

A third response added, *"Mas may saysay ang lesson kapag nakikita nila ang epekto nito sa kalikasan." P12*

Moreover, the integration of environmental contexts aligns with sustainability-oriented science education, which underscores the importance of connecting scientific knowledge to pressing environmental challenges (Tilbury, 2011). When learners explore scientific concepts through issues such as waste management, energy conservation, and ecological balance, they not only deepen their conceptual understanding but also develop environmental awareness and a sense of responsibility. This dual focus on cognitive understanding and environmental relevance enhances the educational value of science instruction, reinforcing the idea that contextualized, sustainability-linked learning fosters both academic achievement and responsible citizenship.

Theme 2: Experiential and Inquiry-Based Learning through Clean and Green Activities

Learners engaged in a range of hands-on and inquiry-based activities designed to actively involve them in the exploration of scientific concepts through Clean and Green initiatives. Activities such as waste segregation experiments required learners to classify materials based on their physical and chemical properties, encouraging them to apply scientific reasoning while developing practical skills related to environmental management. Through water testing activities, learners examined water quality by observing indicators such as clarity, odor, and potential contaminants, which allowed them to connect concepts in Chemistry such as solutions, mixtures, and chemical properties—to real-life environmental concerns affecting their community.

Participant Responses:

The participant shared, *"Mas aktibo ang mga bata kapag sila mismo ang nag-eeksperimento." P4*
Another response stated, *"Mas madaling matandaan ang lesson kapag may aktwal na gawain." P15*
A third noted, *"Natututo sila hindi lang sa libro kundi sa ginagawa nila."P10*

Experiential learning fosters deeper understanding by engaging learners both physically and cognitively in the learning process, allowing them to construct knowledge through direct experience and reflective thinking. According to Kolb's (1984) experiential learning model, learning occurs through a cyclical process that involves concrete experience, reflective observation, abstract conceptualization, and active experimentation. In the context of science instruction, hands-on and inquiry-based activities enable learners to move through these stages by first engaging in real-world tasks, reflecting on their observations, linking experiences to scientific concepts, and applying new understandings to solve problems or explain phenomena.

Theme 3: Interdisciplinary Connections and Environmental Awareness

Clean and Green initiatives enabled meaningful interdisciplinary integration across Chemistry, Physical Science, and environmental education by serving as a unifying context through which concepts from multiple disciplines were taught and reinforced. Environmental activities such as waste management, recycling, water conservation, and energy efficiency provided authentic situations where chemical principles (e.g., properties of materials, chemical reactions, decomposition), physical science concepts (e.g., energy transformation, heat transfer, forces), and environmental education themes (e.g., sustainability, ecological responsibility) could be addressed simultaneously. This integration allowed learners to see how scientific knowledge operates across disciplinary boundaries rather than as isolated subject areas.

Participant Responses:

One response explained, *"Napag-uugnay namin ang Science, Health, at Environmental Education sa isang activity." P6*
Another noted, *"Mas nakikita ng mga estudyante na magkakaugnay ang mga asignatura." P8*
A third added, *"Nagiging mas responsable sila sa kapaligiran." P11*

Interdisciplinary instruction supports holistic learning by enabling learners to apply scientific knowledge across multiple domains and to understand concepts as interconnected rather than isolated. Drake and Burns (2004) emphasize that integrating subject areas helps learners make meaningful connections between ideas, thereby promoting deeper understanding and more flexible application of knowledge. When learners encounter scientific concepts within interdisciplinary contexts, they are better able to transfer learning to new situations and recognize the relevance of science to real-world issues.

Similarly, Sterling (2010) argues that interdisciplinary approaches are essential for addressing complex sustainability challenges, as such issues cannot be adequately understood through a single disciplinary lens. By integrating Chemistry, Physical Science, and environmental education, learners develop systems thinking and a more comprehensive perspective on environmental problems. This holistic approach not only enhances conceptual understanding but also fosters critical thinking, problem-solving, and responsible decision-making, which are central goals of contemporary science education.

Theme 4: Teacher Agency and Adaptive Pedagogy amid Constraints

Despite challenges such as limited instructional time, shortages of materials, and the absence or limited availability of laboratory facilities, the teacher demonstrated adaptability in sustaining sustainability-focused teaching. Instructional strategies were modified to fit available resources, with greater emphasis placed on outdoor learning spaces, improvised materials, and school-based environmental activities as alternatives to traditional laboratory experiments. Lessons were carefully planned to maximize limited class time, often integrating sustainability concepts into regular instructional activities rather than treating them as separate lessons.

Participant Responses:

One response stated, *"Kailangan talagang maging creative at flexible." P3*
Another shared, *"Hindi hadlang ang kakulangan kung may malinaw na layunin." P1*
A third noted, *"Mahalaga ang pagmumuni-muni sa pagtuturo." P9*

This finding aligns with research on teacher agency in environmental education, which emphasizes the importance of teachers' professional judgment, flexibility, and commitment in enacting sustainability-oriented pedagogy (Sterling, 2010; Azano & Stewart, 2016). Sterling (2010) argues that sustainability education requires adaptive and reflective educators who can navigate complex and evolving teaching contexts, while Azano and Stewart (2016) highlight that in rural and resource-constrained settings, teacher agency is often the primary driver of instructional innovation. Together, these perspectives underscore that the successful integration of sustainability pedagogy depends not solely on curriculum mandates or school programs, but on teachers' capacity to reflect, adapt, and lead pedagogical change within their classrooms.

5. Discussion

The findings demonstrate that integrating Clean and Green initiatives into Chemistry and Physical Science instruction enhances learners' conceptual understanding and engagement by situating scientific knowledge within real-life environmental issues that are meaningful and familiar to students. When abstract scientific concepts such as chemical reactions, energy transformation, and matter cycles are contextualized through environmental practices like waste management, recycling, and conservation, learners are better able to make sense of scientific ideas and see their practical value. This supports contextual learning research, which emphasizes that learning becomes deeper and more durable when academic content is connected to authentic situations and learners' everyday experiences (Johnson, 2002; Tilbury, 2011). Contextualization also addresses common difficulties in science learning by reducing abstraction and increasing relevance, particularly in secondary school settings where learner motivation can be a challenge.

Experiential and inquiry-based activities associated with Clean and Green initiatives further supported active learning by engaging learners physically, cognitively, and socially. Hands-on investigations, environmental observations, and problem-solving tasks encouraged learners to ask questions, collect data, and draw evidence-based conclusions, which are central processes in scientific inquiry. Research consistently shows that experiential learning enhances conceptual understanding and retention by allowing learners to construct knowledge through direct experience and reflection (Kolb, 1984). Similarly, inquiry-based science education has been found to improve learners' motivation, critical thinking, and scientific reasoning by shifting instruction from teacher-centered explanations to learner-driven exploration (Prince & Felder, 2006; Hmelo-Silver et al., 2007). In this study, experiential engagement with environmental activities enabled learners to actively participate in learning rather than passively absorb information.

Interdisciplinary connections across Chemistry, Physical Science, and environmental education further reinforced the relevance and coherence of science instruction. By integrating multiple subject areas through Clean and Green initiatives, learners were able to see how scientific concepts intersect and contribute to understanding complex environmental problems. Drake and Burns (2004) argue that interdisciplinary instruction promotes holistic learning by helping learners transfer knowledge across domains, while Sterling (2010) emphasizes that sustainability education requires integrated perspectives to address real-world challenges. These interdisciplinary approaches supported systems thinking and allowed learners to apply scientific knowledge in broader social and environmental contexts, thereby strengthening the educational value of science instruction.

This finding aligns with research highlighting the importance of teacher agency and leadership in instructional innovation, especially in rural and under-resourced schools (Sterling, 2010; Azano & Stewart, 2016). When

teachers exercise professional judgment and flexibility, they are better positioned to transform school-based initiatives into meaningful learning opportunities. Collectively, these findings underscore that sustainability-integrated science instruction is most effective when supported by contextualized pedagogy, experiential learning, interdisciplinary connections, and strong teacher agency.

6. Conclusion

This study provides evidence that Clean and Green initiatives can serve as effective pedagogical resources in Chemistry and Physical Science instruction by transforming sustainability activities into meaningful learning contexts rather than treating them as peripheral or compliance-driven programs. When environmental initiatives are intentionally aligned with curriculum goals and scientific concepts, they create authentic opportunities for learners to apply abstract knowledge to real-life environmental issues, thereby enhancing conceptual understanding and relevance.

The findings further indicate that the successful integration of Clean and Green initiatives depends largely on reflective and adaptive teaching practices. By continuously reflecting on learner responses and adjusting instructional strategies to suit contextual realities, the teacher was able to sustain sustainability-focused instruction despite constraints in time, materials, and facilities. Such reflective practice allowed sustainability initiatives to be embedded meaningfully into daily lessons, supporting active learning, inquiry, and interdisciplinary connections. As a result, learners not only demonstrated increased engagement but also developed a more coherent understanding of how scientific knowledge relates to environmental stewardship.

However, sustaining these pedagogical innovations requires institutional support beyond individual teacher efforts. Ongoing professional development is essential to equip teachers with the knowledge, skills, and confidence needed to integrate sustainability themes effectively into subject instruction. In addition, supportive school leadership, access to instructional resources, and policies that recognize sustainability-oriented pedagogy as part of core teaching practice are critical for long-term implementation. Without such support structures, the integration of Clean and Green initiatives risks remaining sporadic and teacher-dependent rather than becoming a sustained and systemic feature of science education.

7. Implications and Recommendations

Teachers are encouraged to integrate environmental initiatives into science instruction to contextualize learning and promote sustainability. School leaders should support professional development focused on sustainability pedagogy and inquiry-based science teaching. Future research may employ multiple case studies or mixed-methods designs to examine the impact of sustainability-integrated science instruction on learner achievement and environmental attitudes.

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