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## Integrating Deming and Six Sigma Principles in School Greenship Initiatives: A Narrative Inquiry Perspective

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**Abstract:** This research examines how combining Deming's Plan-Do-Check-Act (PDCA) Cycle with Six Sigma's DMAIC (Define, Measure, Analyze, Improve, Control) principles can strengthen green initiatives in schools as part of sustainable education governance. Adopting a narrative inquiry design, the study captures the lived experiences of principals, teachers, and facility coordinators in executing environmentally responsible practices in accordance with the Greenship standards of the Green Building Council Indonesia (GBCI). Data were gathered through in-depth interviews and document analyses from selected environmentally oriented schools. The results indicate that integrating Deming and Six Sigma methodologies facilitates more systematic planning, monitoring, and evaluation of sustainability efforts, thereby enhancing environmental efficiency, resource optimization, and a culture of continuous improvement across the school community. The study underscores that the effectiveness of Greenship implementation relies not only on adherence to technical standards but also on collaborative leadership, active stakeholder participation, and reflective learning processes. Ultimately, this work contributes to the discourse on sustainable school management by proposing a practical model that connects quality improvement systems with environmental accountability in educational institutions.

**Keywords:** Greenship, Deming Cycle, Six Sigma, Green Schools, Green Education Management

### INTRODUCTION

In recent years, the pursuit of sustainability in education has gained significant momentum as schools increasingly recognize their dual role as learning institutions and agents of environmental transformation. Educational leaders now view sustainable school management not only as a moral imperative but also as an operational strategy that enhances institutional resilience and accountability. Integrating green building principles into school systems has thus become essential to advancing environmental stewardship and strengthening governance structures through sustainable education frameworks. (UNESCO, 2024).

The Green Building Council Indonesia (GBCI), through its Greenship rating system, encourages educational institutions to adopt environmentally responsible design, construction, and management practices. Despite these efforts, the adoption rate remains relatively low—

only about 60 buildings in Indonesia were certified as green by 2023 (Amani, 2024). This limited uptake underscores the need for a more structured, process-oriented approach to implementing and maintaining Green ship standards in schools, emphasizing leadership, continuous improvement, and stakeholder collaboration.

To achieve this, many scholars have turned to quality management methodologies, which provide systematic frameworks for institutional improvement (Khairil & Ahmad, 2021). Among these, Deming's Plan-Do-Check-Act (PDCA) cycle and Six Sigma's Define-Measure-Analyze-Improve-Control (DMAIC) framework have proven highly effective for promoting process efficiency, data-driven decision-making, and continuous learning (Arumugam et al., 2022). In educational settings, Lean Six Sigma (LSS) initiatives have improved teaching quality, minimized waste, and optimized administrative operations (Samuel & Farrer, 2025). Likewise, the PDCA cycle has been widely used to strengthen educational quality assurance by promoting reflective practice, feedback loops, and evidence-based evaluation (Abualfaraa et al., 2023).

However, despite their success in manufacturing and higher education contexts, the integration of the PDCA and DMAIC frameworks in green school governance remains underexplored. Previous studies on Green ship implementation have mainly focused on technical compliance and environmental performance such as energy conservation, water efficiency, and waste management without examining how managerial processes and quality systems can sustain these efforts over time (Huan & Mohamad Nasri, 2022). Few studies have explored how quality management approaches can reinforce sustainable school leadership and foster organizational learning that supports environmental accountability.

Addressing this research gap, the present study investigates how combining Deming's PDCA cycle with Six Sigma's DMAIC principles can strengthen green shipping initiatives within a holistic model of sustainable education governance. Using a narrative inquiry approach, this study captures the lived experiences of principals, teachers, and facility managers as they implement environmentally responsible programs aligned with GBCI's Green Ship standards. Through in-depth interviews and document analysis conducted from 2023 to 2025 in selected environmentally oriented schools, this study aims to identify how quality management methodologies can be effectively adapted to drive sustainability-oriented change in education. (Arafeh et al., 2021).

By integrating process improvement and environmental stewardship, this research contributes to the evolving discourse on green education management. It proposes a practical and replicable framework that bridges quality assurance systems with sustainable school leadership, supporting long-term institutional transformation toward ecological and organizational excellence.

## **METHOD**

The research method contains the type of research, sample and population or research subjects, time and place of research, instruments, procedures, and research techniques, as well as other matters relating to the method of research. This section can be divided into several sub-chapters, but no numbering is necessary.

This study employed a qualitative narrative inquiry design to examine how Deming's Plan-Do-Check-Act (PDCA) and Six Sigma's Define-Measure-Analyze-Improve-Control (DMAIC) frameworks are utilized to enhance Green ship initiatives in schools. Narrative inquiry was chosen as it enables a deep exploration of participants' lived experiences, allowing the researcher to capture the personal meanings, interpretations, and reflective practices embedded in the implementation of sustainable school management (Clandinin, 2023). Through this approach, the study uncovers how school leaders, teachers, and facility coordinators understand, adapt, and institutionalize continuous improvement processes within environmentally responsible educational settings.

The research was carried out in three schools in Jakarta and its surrounding areas, all of which have adopted, or are in the process of adopting, the Green ship School principals promoted by the Green Building Council Indonesia (GBCI). A purposive sampling strategy was used to identify participants who had substantial involvement in sustainability programs and school management (Ilker Etikan; Sulaiman Abubakar Musa, 2016). The final sample included 12 participants: three principals, six teachers, and three facility managers, each with at least 2 years of direct experience with green initiatives or quality assurance systems in their institutions.

Data collection was conducted through semi-structured interviews lasting 45-60 minutes, depending on participants' availability. Interviews were held both face-to-face and online to ensure accessibility and convenience. All interviews were recorded with the participants' consent and transcribed verbatim for analysis.

The collected data were analyzed using thematic narrative analysis, following the stages of data familiarization, coding, theme development, and interpretative synthesis. (Braun & Clarke, 2023). The emergent themes were categorized into three overarching domains: 1) Integration of PDCA and DMAIC processes within Green ship implementation, 2) Leadership practices and stakeholder collaboration, and 3) Institutional learning and the development of a sustainability-oriented culture.

To uphold ethical research standards, all participants provided informed consent before participation. Their identities were anonymized using pseudonyms, and participation was entirely voluntary, with the option to withdraw at any stage without any penalty. All data were securely stored on encrypted drives and will be retained for five years solely for academic verification and audit purposes.

## **RESULTS AND DISCUSSION**

### **a. Integrating PDCA and DMAIC for Systematic Sustainability Management**

The narratives revealed that schools applying Green ship principles through the integrated PDCA–DMAIC framework demonstrated greater coherence between strategic objectives and operational implementation. Both principals and facility managers reported using the Plan–Do–Check–Act (PDCA) cycle to conduct regular sustainability reviews focusing on energy conservation, waste reduction, and water efficiency. Simultaneously, the Define–Measure–Analyze–Improve–Control (DMAIC) process provided a quantitative structure for tracking performance indicators, diagnosing inefficiencies, and driving targeted improvements.

For instance, one school in Jakarta employed the PDCA model to design and evaluate its rainwater harvesting system, followed by DMAIC analytical tools, such as Pareto charts, fishbone diagrams, and root-cause analyses, to identify water-loss factors. As a result, the school successfully reduced its non-recycled water use by 15% within six months, demonstrating tangible improvement in both environmental and operational outcomes. This integrated framework fostered a dual orientation: reflective learning and adaptation supported by PDCA, and data-driven precision facilitated by DMAIC. Together, these processes established a culture of continuous improvement grounded in evidence and accountability.

These findings are consistent with earlier studies highlighting the synergistic relationship between Lean Six Sigma methodologies and Deming's continuous improvement cycle in developing institutional sustainability systems (Barcia et al., 2022). The structured integration of both approaches encourages a shift from symbolic or compliance-based sustainability actions to measurable, iterative progress. (Abualfaraa et al., 2023). Schools adopting this hybrid model thus benefit from a systematic pathway for embedding sustainability into their governance and daily practices.

### **b. Leadership and Stakeholder Collaboration as Catalysts for Green ship Success**

Leadership emerged as a critical catalyst for the effective implementation of Green ship practices. Principals who intentionally fostered inclusive participation engaging teachers, students, maintenance staff, and parents demonstrated greater success in cultivating shared ownership and long-term commitment to sustainability goals (Rifai et al., 2024). Many school leaders established Green Teams that conducted monthly PDCA reviews of ongoing sustainability initiatives, using DMAIC-based diagnostics to assess performance metrics such as energy use, classroom ventilation, and waste segregation efficiency.

Teachers described this leadership style as participative rather than hierarchical, empowering all members of the school community to contribute ideas and take collective responsibility for continuous improvement. This finding aligns with (Budiman, 2022), who emphasized that sustainable education governance is most effective when grounded in distributed leadership and collaborative reflection rather than rigid, top-down control structures.

Collaboration also extended beyond school boundaries. Engagement with parents, alumni, and local communities amplified the impact of sustainability initiatives (Rifai et al., 2024). For example, a Bandung-based school partnered with surrounding residents to implement a composting program that converted organic waste into fertilizer, directly supporting GBCI's Site and Waste Management criteria. Such partnerships not only reduced waste but also enhanced environmental literacy and strengthened community-school relations. These outcomes are consistent with (Kurniawan et al., 2023), who found that community participation significantly enhances ecological performance and Green ship compliance.

### **c. Institutional Learning and the Culture of Continuous Improvement**

The data also illustrated that sustainability transformation represents an ongoing process of organizational learning, rather than a single accomplishment. Through iterative application of PDCA and DMAIC, schools cultivated routines of reflection, documentation, and adaptation that institutionalized learning within daily operations (Vilaça et al., 2025). Teachers reported becoming more mindful of environmental indicators, while facility managers systematically documented energy and water usage patterns and implemented corrective measures. (Irawan et al., 2024).

This process resonates with Deming's concept of the "learning organization," where feedback loops are leveraged to promote not only immediate problem-solving but also long-term systemic development. (Rahmaniza, 2025). The schools studied demonstrated visible cultural shifts, staff members proactively identified inefficiencies, students initiated eco-projects, and decision-making processes increasingly relied on sustainability metrics and evidence-based evaluations. (Hamza et al., 2020).

Such outcomes reinforce the assertion that integrating quality assurance frameworks with environmental stewardship yields a holistic, self-reinforcing model of sustainable school management (Braun & Clarke, 2023). Within this model, ecological responsibility, educational quality, and social collaboration interact dynamically to create a resilient institutional ecosystem capable of sustaining continuous growth and innovation.

### **d. Discussion Summary**

Overall, the findings affirm that integrating the PDCA and DMAIC frameworks enhances schools' organizational coherence, accountability, and learning capacity. The hybrid approach empowers schools to systematically embed sustainability into their strategic and operational dimensions, while continuously measuring, analyzing, and improving their environmental and managerial performance (Marques et al., 2025).

The study contributes to both theoretical and practical understanding by demonstrating how industrial quality management tools can be effectively contextualized to advance educational sustainability. This adaptation not only fills the research gap identified by

(Kurniawan et al., 2023) but also provides empirical evidence for the design of future models of sustainable education governance in developing countries (Izuchukwu Precious et al., 2025).. The findings further suggest that fostering a reflective, data-driven, and collaborative culture is essential to achieving long-term environmental accountability in educational institutions.

## CONCLUSION

This study concludes that integrating Deming's Plan-Do-Check-Act (PDCA) cycle with Six Sigma's Define-Measure-Analyze-Improve-Control (DMAIC) framework provides a comprehensive and adaptable model for advancing Green ship initiatives in educational institutions. Through a narrative inquiry approach, the research demonstrates how combining these quality management methodologies helps schools adopt more systematic, data-informed, and reflective approaches to sustainability management. (Clandinin, 2023; Braun & Clarke, 2023).

The findings indicate that the PDCA cycle plays a central role in structuring planning, implementation, and evaluation processes, fostering a culture of reflection and adaptive learning among school leaders and staff. Meanwhile, the DMAIC framework enhances this foundation by introducing analytical precision facilitating data collection, performance monitoring, and targeted problem-solving (Antony et al., 2017). When combined, these complementary processes enable schools to transition from fragmented, compliance-based environmental efforts to holistic systems of sustainability governance embedded in everyday routines and decision-making practices (Pernollet et al., 2017).

Moreover, the study highlights that the success of green ship implementation is shaped not only by procedural adherence but also by collaborative leadership, stakeholder engagement, and institutional learning. Principals, teachers, students, and community members who participated in shared sustainability initiatives developed a stronger sense of ownership and environmental responsibility, reinforcing the idea that sustainability must be both technically managed and ethically grounded. (Wals, 2011; Qadach et al., 2019). This aligns with findings by (Kurniawan et al., 2023), who emphasize that community participation significantly strengthens environmental performance and Green ship compliance.

By contextualizing industrial quality management tools for educational sustainability, this research provides a novel perspective on green school governance, particularly valuable for developing countries where institutional capacity is often limited. (Janulewicz et al., 2023). The integration of PDCA and DMAIC offers a replicable pathway that aligns continuous improvement with environmental stewardship, bridging the long-standing gap between quality assurance systems and sustainable education practices.

Ultimately, this study proposes that institutions adopting this dual-framework model can cultivate more resilient, responsible, and future-oriented school ecosystems where sustainability becomes a lived practice embedded in organizational culture rather than a mere policy aspiration.

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