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Research Article

Green Building Standards and Their Application in Retrofitting Educational Buildings in South Africa

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DOI: <https://doi.org/10.66408/abc2.2025.14>

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Abstract

The retrofitting of educational buildings for improved sustainability and energy efficiency is crucial in the fight against climate change. Green building standards (GBS) provide a structured approach to enhancing building performance, reducing carbon footprints, and promoting sustainable practices. This study investigates the application of green building standards in retrofitting educational buildings in South Africa using a survey research design. The study examines the extent to which GBS, such as the Green Star SA rating system, SANS 10400-XA energy efficiency regulations, and other international frameworks, are adopted in retrofitting projects. A structured questionnaire was administered to architects, engineers, facility managers, construction managers, and Quantity Surveyors involved in the retrofitting of educational buildings across Gauteng province in South Africa. To achieve the aim of the study, this paper assessed the level of awareness, implementation challenges, and perceived benefits of integrating GBS into retrofitting projects. Descriptive and inferential statistical analyses were conducted to identify trends and relationships in the data. The findings reveal that while there is growing awareness of GBS in the retrofitting sector, its application remains inconsistent due to financial constraints, regulatory challenges, and limited technical expertise. Despite these challenges, the study found that retrofitting projects incorporating GBS yielded significant benefits, including reduced energy consumption, improved indoor environmental quality, and enhanced building longevity. The study concludes that a more structured approach, supported by policy interventions, financial incentives, and training programs, is essential to mainstream the adoption of green building standards in retrofitting educational buildings in South Africa.

Keywords: Educational buildings; Green building standards; Retrofitting; South Africa; Sustainability

Highlights

- Inconsistent GBS adoption stems from financial, regulatory, and expertise-related challenges.
- Retrofitted schools using GBS show improved energy efficiency and indoor environmental quality.
- Policy support, incentives, and training are vital to mainstream GBS in South African retrofits.

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Received: 04/04/2025

Revised: 03/09/2025

Accepted: 09/12/2025

Published: 13/12/2025

Volume: 2025

Issue: 01

Pages: 68-78

1 Introduction

Most educational buildings in South Africa were constructed decades ago and often lack the design features necessary for energy efficiency and environmental sustainability (Idowu et al., 2024a). These facilities typically depend on electricity from fossil fuels, particularly coal, contributing significantly to greenhouse gas emissions (Idowu et al., 2024b). In the face of climate change, rising energy costs, and increasing pressure to reduce national carbon footprints, there is a growing need to improve the environmental performance of existing school infrastructure (Gamarra et al., 2018). Retrofitting, which helps in upgrading and enhancing the performance of existing buildings, has emerged as a practical and cost-effective strategy for addressing these challenges.

Retrofitting offers multiple benefits, such as extending the life of existing structures, improving indoor environmental quality, reducing energy and water consumption, and lowering operational costs (Ortiz, Itard & Bluysen, 2020). Retrofitting can also enhance thermal comfort, lighting quality, and air circulation, all of which are linked to better learning outcomes and well-being for both students and staff. However, to achieve meaningful and measurable improvements, retrofitting efforts must follow structured, science-based guidelines, and this is where green building standards become essential (Vierra, 2016).

Green building standards provide technical criteria and performance benchmarks that support sustainable design, construction, and renovation practices (Shan & Hwang, 2018; Vierra, 2018). These standards emphasise energy efficiency, resource conservation, the use of environmentally responsible materials, and the creation of healthy indoor environments (Šujanová et al., 2019). In South Africa, frameworks such as SANS 10400-XA, which sets out energy efficiency requirements in building design, and the Green Star SA rating system, developed by the Green Building Council of South Africa (GBCSA), play a central role in guiding sustainable retrofitting projects (Makgalemele, 2021). Abulibdeh (2024) revealed that applying these standards to educational facilities presents an opportunity not only to reduce environmental impacts but also to transform schools into models of sustainability and resilience. Furthermore, the integration of green principles into educational settings can foster environmental awareness among learners, reinforcing sustainable values in future generations (Chavula et al., 2024).

Despite these advantages, the implementation of green building standards in public school retrofitting projects remains limited (Jagarajan et al., 2017). Financial constraints, lack of technical expertise, policy fragmentation, and minimal stakeholder awareness are among the primary barriers (Idowu et al., 2024a). Overcoming these obstacles requires a coordinated approach involving government support, institutional capacity-building, and access to funding mechanisms. This paper investigates the role of green building standards in the retrofitting of educational buildings in South Africa. It examines the relevance and application of national frameworks, evaluates their potential impact on building performance and educational outcomes, and challenges. By doing so, the study aims to contribute to the growing discourse on sustainable infrastructure development in the educational sector and support efforts toward a low-carbon, climate-resilient future.

2 Literature Review

2.1 Green Building Standards and Frameworks

Green building standards have become central tools in guiding sustainable construction and retrofitting practices worldwide (Jagarajan et al., 2017). These standards are designed to promote environmental responsibility, resource efficiency, and human well-being across the life cycle of a building from design and construction to operation and maintenance. Internationally, well-established frameworks such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and WELL Building Standard have demonstrated significant influence in shaping sustainable building practices across both the Global North and South (Dwaikat & Ali, 2016).

In South Africa, green building standards have been localised to address specific environmental conditions, resource constraints, and socio-economic realities (Imafidon, Enwerem, & Boye, 2024). The Green Star SA rating system, launched in 2008 by the Green Building Council of South Africa (GBCSA), provides an

assessment tool for evaluating the environmental performance of new and existing buildings (Hoffman et al., 2020). This system measures multiple sustainability categories, including energy, water, indoor environmental quality, materials, emissions, and innovation. Though initially developed for commercial buildings, Green Star SA has expanded to include custom tools for public sector buildings, including schools.

The successful retrofitting of educational buildings in South Africa depends largely on the adoption of green building standards (Amoah & Smith, 2024). These standards provide frameworks for improving the energy and resource efficiency of buildings, fostering environmental sustainability while creating healthier learning environments (Rifaat & Nassar, 2025). The most frequently referenced green standards in the reviewed literature include SANS 204, Green Star SA, and international standards like LEED and EDGE, alongside national policy frameworks designed to support sustainability in educational infrastructure.

SANS 204 10400-XA framework focuses on energy efficiency and is widely cited as a critical standard in the retrofitting of South African schools (Moodley & Tramontin, 2015). This standard addresses the importance of passive design strategies, such as optimising building orientation, enhancing natural ventilation, and improving thermal insulation. The literature suggests that implementing SANS 204 principles can significantly reduce the operational costs of educational buildings by lowering energy consumption for heating, cooling, and lighting. It was introduced in 2011 and updated in subsequent years. It aligns with South Africa's commitments under the National Energy Efficiency Strategy and contributes to the country's broader goals under the Nationally Determined Contributions (NDCs) to climate mitigation. Studies by Makaka and Meyer (2006) and Du Plessis (2012) have emphasised the potential of green standards to significantly reduce building-related emissions and improve resource use efficiency. However, the application of these standards in educational facilities, especially older public schools, has remained limited due to technical, institutional, and financial barriers.

The Green Star South Africa (SA) rating system was developed to evaluate the overall sustainability of buildings, with specific tools available for different building types, including schools. This rating system assesses various aspects of sustainability, such as energy efficiency, water conservation, indoor environmental quality, and the use of sustainable materials. Studies in the review indicated that Green Star SA was widely acknowledged for its comprehensive approach to sustainability, which includes both environmental and health-related factors. However, while the Green Star SA rating system is well-regarded, its adoption in the educational sector has been limited due to the high initial costs associated with certification and retrofitting. Despite this, the Green Star SA tool remains an important framework for large-scale educational projects and for setting benchmarks for sustainability.

Both LEED (Leadership in Energy and Environmental Design) and EDGE (Excellence in Design for Greater Efficiencies) were mentioned as applicable standards for retrofitting educational buildings in urban areas and larger-scale public sector projects. LEED, an international standard, focuses on environmental sustainability across a wide array of building types, while EDGE, which is specifically designed for developing countries, targets resource-efficient buildings through cost-effective methods. While the application of these standards in South Africa is still relatively limited, their relevance is growing. EDGE, in particular, is seen as a more accessible standard for schools in developing regions due to its emphasis on achieving environmental goals at a lower cost, making it an attractive option for educational institutions with limited budgets.

National and local policies, such as the Green Economy Framework, National School Infrastructure Norms, and Energy Efficiency and Demand Side Management Regulations, play a significant role in shaping the retrofitting landscape for educational buildings. These policies often provide overarching guidelines but are not always backed by the necessary funding, technical support, or clear enforcement mechanisms. While national frameworks advocate for the integration of green building practices, the actual on-the-ground implementation of these policies often lacks the coordination required across various levels of government. The absence of a strong regulatory framework has resulted in inconsistent application and enforcement of green standards, particularly in rural areas.

2.2 Green Building Standards and Frameworks

Retrofitting educational buildings plays a crucial role in global efforts to improve environmental sustainability and address climate change. Educational buildings, due to their high occupancy rates and long operational hours, consume significant energy and water resources. Retrofitting offers an opportunity to upgrade these structures to modern energy-efficient standards while avoiding the economic and environmental costs of demolition and new construction.

Globally, countries such as the United States, Germany, and Australia have invested heavily in retrofitting school buildings. For example, the Green Schools Initiative in the U.S. and Germany's Energy Efficient Schools Programme have demonstrated that retrofitting can reduce energy use by up to 40%, lower utility bills, and improve thermal comfort and indoor air quality (Kats, 2006; Schneider, 2002). These programs are typically supported by public funding, strong regulatory frameworks, and national green building policies, which collectively create an enabling environment for sustainable retrofitting.

In South Africa, educational retrofitting efforts are still emerging. Most public schools were built before energy efficiency regulations were introduced and were not designed to accommodate future upgrades (Stephen et al., 2024). As a result, these buildings typically suffer from poor insulation, lack of passive design features, outdated lighting systems, and inefficient HVAC (heating, ventilation, and air conditioning) systems. According to research by Musango et al. (2019), South African schools present significant opportunities for retrofitting, particularly in areas such as daylight optimisation, solar energy integration, and natural ventilation.

Several demonstration projects have illustrated the feasibility and benefits of school retrofitting in South Africa. The Green School South Africa in Paarl, for example, showcases how a net-zero carbon and off-grid school can function in a local context using biophilic design, renewable energy, and on-site water recycling. While this model is privately funded and high-end, it offers valuable insights into what can be achieved with the right design and commitment to sustainability. Despite these examples, large-scale retrofitting of public schools remains constrained. The Department of Basic Education's (DBE) Infrastructure Delivery Management System (IDMS) provides a framework for infrastructure upgrades, but sustainability considerations are often secondary to urgent service delivery issues such as sanitation, classroom space, and safety. As such, integrating retrofitting into mainstream education infrastructure planning requires both policy alignment and increased capacity within education departments at all levels.

2.3 Challenges and Opportunities in Applying Green Standards in Schools

The application of green building standards in the retrofitting of educational buildings faces several complex challenges in South Africa (Adekunle et al., 2024). Foremost among these is the financial constraint. Retrofitting can be capital-intensive, and most public schools operate under tight budgets with limited access to financing. Unlike commercial buildings, schools do not directly benefit from energy cost savings in a way that allows for reinvestment, which makes the case for retrofitting more difficult to justify without external funding (Elkhapery, Kianmehr & Doczy, 2021). Technical barriers also persist as many schools lack access to skilled professionals capable of conducting energy audits, designing retrofits, or managing green building certification processes (Amoah & Smith, 2024). There is also limited awareness among school administrators and policymakers regarding the benefits of green retrofitting and how to access existing support mechanisms, such as GBCSA's tools or government energy-efficiency rebates.

Policy fragmentation adds another layer of complexity. While South Africa has strong national climate policies, such as the National Climate Change Response Strategy (NCCRS) and the Just Energy Transition Framework, these are not always well integrated into the planning and execution of education infrastructure projects. As noted by Altassan (2023), there is a need for clearer policy coordination between the Departments of Basic Education, Energy, Environment, and Public Works to facilitate sustainable building practices in schools. Despite these barriers, there are significant opportunities. International financing instruments, such as the Green Climate Fund, climate bonds, and development finance institutions, present funding opportunities for large-scale retrofitting programs. Additionally, the growing political momentum around climate action and social equity in South Africa, focus on inclusive development, creates a

favourable environment for positioning school retrofitting as part of broader green recovery and social upliftment strategies (Adebayo, 2025).

Furthermore, retrofitting schools offers educational benefits beyond the physical infrastructure. Incorporating sustainability into the school environment can serve as a living lab for students, helping to embed environmental consciousness and stewardship in the curriculum. This aligns with the goals of Education for Sustainable Development (ESD), as promoted by UNESCO, and enhances the long-term societal impact of green building efforts (Idowu et al., 2024c). This section establishes the intellectual and theoretical basis for the study, providing a structured analysis of key concepts, relevant theories, and existing frameworks that inform the research. It critically reviews the literature to position the study within the broader academic discourse, identifying gaps the research seeks to address. Additionally, it introduces a conceptual model that guides the study's approach, offering a lens through which the research problem is examined.

3 Existing Theories and Frameworks

The retrofitting of educational buildings for sustainability is grounded in a number of interrelated theories and frameworks that guide design, implementation, and evaluation. This section discusses the theoretical and regulatory foundations that underpin the application of green building standards (GBS) in retrofitting practices.

3.1 Sustainability and Systems Theory

Sustainability in the built environment is underpinned by systems theory, which views buildings as components within larger environmental, social, and economic systems. Retrofitting, therefore, is not merely a technical intervention but a systemic change that impacts energy flows, resource use, and occupant wellbeing. The systems perspective emphasises interdependencies between building operations and ecological outcomes, reinforcing the need for integrated green building approaches.

3.2 Diffusion of Innovation Theory

The Diffusion of Innovation (DoI) Theory, developed by Rogers (1962), explains how new ideas and technologies spread within a social system. The theory is particularly relevant in understanding how green building standards are adopted among professionals involved in retrofitting educational buildings. Key factors such as perceived benefits, compatibility, complexity, trialability, and observability influence the rate of adoption of GBS practices. The study applies this framework to assess stakeholders' awareness and acceptance of standards like Green Star SA and SANS 10400-XA.

3.3 The Triple Bottom Line Framework

The Diffusion of Innovation (DoI) Theory, developed by Rogers (1962), explains how new ideas and technologies spread within a social system. The theory is particularly relevant in understanding how green building standards are adopted among professionals involved in retrofitting educational buildings. Key factors such as perceived benefits, compatibility, complexity, trialability, and observability influence the rate of adoption of GBS practices. The study applies this framework to assess stakeholders' awareness and acceptance of standards like Green Star SA and SANS 10400-XA.

4 Methodology

This study adopted a quantitative survey research design to investigate the application of green building standards (GBS) in the retrofitting of educational buildings in South Africa. The survey design was selected for its effectiveness in gathering structured responses from various professionals involved in building retrofitting projects. This approach allowed for the systematic data collection and analysis on awareness levels, implementation practices, challenges, and perceived benefits associated with GBS. The research was conducted in Gauteng Province, the economic hub of South Africa, with a high concentration of educational infrastructure development and retrofitting activity. Gauteng was selected due to its diversity of school types, high urbanisation rate, and accessibility to build environment professionals. The target population

comprised built environment professionals directly involved in retrofitting educational buildings. These include architects, engineers (mechanical, electrical, structural), facility managers, project managers, and quantity surveyors.

A purposive sampling technique was employed to identify professionals with practical experience or involvement in at least one retrofitting project of an educational facility within the last five years. This ensured that respondents had relevant insights into applying green building standards in practice. 150 questionnaires were distributed to selected professionals across public and private sector firms, with 108 valid responses received, representing a response rate of 72%. To ensure content validity, the questionnaire was reviewed by experts in sustainable building design and retrofitting. A pilot test involving 10 professionals from the target population was conducted to refine the instrument for clarity and relevance. Reliability of the instrument was tested using Cronbach’s alpha, with values ranging from 0.78 to 0.86 across the key constructs, indicating acceptable internal consistency. Data were analysed using mean score, standard deviation, and ranking.

5 Results- Key Findings

5.1 Background Information of Respondent

The demographic summary of survey respondents in the study area indicates that 25% are Quantity Surveyors, 20% are Architects, 24% are Engineers, 26% are Facility Managers, and 5% are Project Managers. A significant proportion of the respondents have at least 10 years of experience. Regarding professional qualifications, 85% are corporate members of their respective professional bodies, while 15% are probationer members. Regarding post-professional qualification experience, 50% have between 1 to 5 years, 25% have 6 to 10 years, and another 25% have 11 to 15 years, with an average of 6.67 years. The predominance of experienced respondents enhances the reliability of the data for this research.

5.2 Level of Awareness of Green Building Standards

Table 1 shows the level of awareness of respondents of the various green building standards. Ranking first is green star SA with a mean score (MS) of 3.73 and Standard deviation (SD) of 0.92, followed by SANS 10400-XA (SA energy efficiency regulation) (MS = 3.43, SD 1.06) and National Building Regulation part XA (MS = 3.29, SD 1.04). Leadership in Energy and Environmental Design (LEEDS) ranked fourth with (MS=3.05, SD= 1.09), SA energy performance certificate for buildings ranked fifth with (MS=3.03, SD=1.07), Excellence in Design for Greater Efficiencies (EDGE) ranked sixth with (MS=3.01, SD=1.12), ISO 50001 (Energy Management System) ranked seventh with (MS=2.68, 1.10), Net Zero Carbon Building Standard ranked eighth with (MS=2.42, SD= 1.08). Building Research Establishment standard (BREEAM) UK ranked least with (MS=2.13, SD=1.15), followed by WELL Building Standard (Health & Wellness) and Green Lease Toolkit (Green contracts and operations) with (MS=2.21, SD=1.12) and (MS=2.28, SD=1.11) respectively.

Table 1: Level of awareness of green building standards.

Green Building Standard	Mean Score	SD	Rank
Green Star SA	3.73	0.92	1
SANS 10400-XA (SA energy efficiency regulations)	3.43	1.06	2
National Building Regulations Part XA (SANS 204)	3.29	1.04	3
LEED (Leadership in Energy and Environmental Design)	3.05	1.09	4
SA Energy Performance Certificates (EPCs) for buildings	3.03	1.07	5
EDGE (Excellence in Design for Greater Efficiencies)	3.01	1.12	6
ISO 50001 (Energy Management System)	2.68	1.10	7
Net Zero Carbon Building Standard	2.42	1.08	8
Green Lease Toolkit (Green contracts and operations)	2.28	1.11	9
WELL Building Standard (Health & Wellness)	2.21	1.12	10
BREEAM (UK Building Research Establishment standard)	2.13	1.15	11

¹ Authors’ work

5.3 Barriers to Implementation of Green Building Standards in Retrofitting

Table 2 shows the barriers to implementing green building standards. Ranking first is the high upfront cost of retrofitting, with a mean score (MS) of 4.52 and a Standard deviation (SD) of 0.74, followed by lack of

technical expertise (MS = 4.20, SD = 0.81) and limited awareness among stakeholders (MS = 4.12, SD 0.79). Inadequate policy enforcement ranked fourth with (MS=4.08, SD= 0.83), insufficient government support or incentives ranked fifth with (MS=3.98, SD=0.85), complexity of certification processes ranked sixth with (MS=3.84, SD=0.87), resistance to change in school management ranked seventh with (MS=3.65, 0.90), limited availability of green materials and technologies ranked eighth with (MS=3.62, SD= 0.88). Lengthy project approval and permitting processes ranked least with (MS=3.32, SD=0.98), followed by Lack of client demand or understanding and Shortage of skilled labour in green construction with (MS=3.40, SD=0.96) and (MS=3.48, SD=0.94) respectively.

Table 2: Barriers to the implementation of green building standards in retrofitting.

Barrier	Mean Score	SD	Rank
High upfront costs of retrofitting	4.52	0.74	1
Lack of technical expertise	4.20	0.81	2
Limited awareness among stakeholders	4.12	0.79	3
Inadequate policy enforcement	4.08	0.83	4
Insufficient government support or incentives	3.98	0.85	5
Complexity of certification processes	3.84	0.87	6
Resistance to change in school management	3.65	0.90	7
Limited availability of green materials and technologies	3.62	0.88	8
Inconsistent implementation guidelines	3.56	0.91	9
Shortage of skilled labour in green construction	3.48	0.94	10
Lack of client demand or understanding	3.40	0.96	11
Lengthy project approval and permitting processes	3.32	0.98	12

¹ Authors' work

5.4 Benefits of Implementing Green Building Standards in Retrofitting

Table 3 shows the benefits of implementing Green Building Standards in Retrofitting. Ranking first is reduced energy consumption and utility costs with a mean score (MS) of 4.61 and a Standard deviation (SD) of 0.68, followed by improved indoor environmental quality (MS = 4.48, SD = 0.72) and enhanced building performance and longevity (MS = 4.37, SD 0.75). Compliance with national and global regulations ranked fourth with (MS=4.25, SD= 0.78), Improved occupant health and comfort ranked fifth with (MS=4.18, SD=0.80), Positive environmental impact ranked sixth with (MS=4.10, SD=0.83), increased stakeholder satisfaction ranked seventh with (MS=4.02, 0.86), Enhanced institutional reputation and public image eighth with (MS=3.95, SD= 0.88), better learning outcomes through improved learning environments ranked ninth with (MS=3.92, SD = 0.89). Increased property resale value of school infrastructure ranked least with (MS=3.68, SD=0.96), followed by alignment with Sustainable Development Goals (SDGs) and access to green finance or sustainability grants with (MS=3.76, SD=0.93) and (MS=3.80, SD=0.91) respectively.

Table 3: Benefits of implementing green building standards in retrofitting.

Benefit	Mean Score	SD	Rank
Reduced energy consumption and utility costs	4.61	0.68	1
Improved indoor environmental quality (IEQ)	4.48	0.72	2
Enhanced building performance and longevity	4.37	0.75	3
Compliance with national and global regulations	4.25	0.78	4
Improved occupant health and comfort	4.18	0.80	5
Positive environmental impact	4.10	0.83	6
Increased stakeholder satisfaction	4.02	0.86	7
Enhanced institutional reputation and public image	3.95	0.88	8
Better learning outcomes through improved learning environments	3.92	0.89	9
Access to green finance or sustainability grants	3.80	0.91	10
Alignment with Sustainable Development Goals (SDGs)	3.76	0.93	11
Increased property resale value of school infrastructure	3.68	0.96	12

¹ Authors' work

6 Discussion

This study assessed the application of Green Building Standards (GBS) in retrofitting educational buildings in South Africa, focusing on levels of awareness, barriers to implementation, and perceived benefits. The

findings reveal important insights into the current state of GBS integration and reflect broader patterns consistent with both local and international research. The results show a relatively high level of awareness of South African-based standards such as SANS 10400-XA and Green Star SA, which ranked first and second, respectively, in awareness among respondents. This aligns with studies by van Wyk, Kajimo-Shakantu, and Opawole (2024), highlighting the increasing uptake and promotion of local green standards in South African construction. The inclusion of energy efficiency requirements in national building codes, specifically in SANS 10400-XA, has helped institutionalise sustainable practices, particularly in urban regions such as Gauteng. However, awareness of international frameworks such as LEED, EDGE, and BREEAM was significantly lower (mean scores ranging between 2.1 and 3.0). The Living Building Challenge had the lowest awareness level, consistent with findings by Darko and Chan (2021), who noted that globally stringent certification systems often have minimal penetration in developing countries due to contextual differences in regulations and market maturity. This disparity in awareness suggests that while local standards are gaining traction, the broader spectrum of global sustainability tools is underutilised. Awareness initiatives and targeted training by professional bodies could bridge this gap, especially for professionals working in international or donor-funded retrofitting projects.

The second dimension of the study identified key barriers to GBS adoption in educational building retrofits. The most significant barriers, as rated by participants, include high upfront costs, lack of technical expertise, limited stakeholder awareness, and inadequate policy enforcement. These results resonate with earlier findings by Abidin and Powmya (2014), who emphasised that cost concerns and insufficient knowledge among stakeholders often impede the adoption of sustainable construction in developing nations. Similarly, studies by Ombati (2023) have reported that the fragmented nature of green policy implementation, lack of professional training, and limited government incentives contribute to the low uptake of GBS in public buildings. Furthermore, barriers such as limited access to green materials and technologies and complex certification processes reflect infrastructural and procedural bottlenecks. This mirrors the challenges noted by Ametepey et al. (2015) in their study of Ghana, where the absence of localised green products and the administrative complexity of certification were major inhibitors. Overall, these findings emphasise the need for multi-level interventions, including financial support mechanisms, clear implementation roadmaps, and capacity-building programs for built environment professionals.

Despite the barriers, respondents acknowledged several strong benefits of applying GBS in retrofitting projects. The benefits echo those cited in international studies, such as by Azhar et al. (2011), which confirm that green buildings deliver long-term economic, health, and environmental gains. Jia et al (2021) found that retrofitting educational institutions to green standards improved the thermal comfort and cognitive performance of learners, a crucial outcome for enhancing educational quality. Interestingly, non-financial benefits, such as institutional reputation, better learning environments, and alignment with SDGs, were rated slightly lower but still above neutral. This suggests that while financial efficiency is a primary driver, broader sustainability goals are gaining recognition. This is a positive shift from earlier narratives where green design was viewed as a luxury rather than a necessity in the South African public sector.

The interplay between awareness, barriers, and benefits reveals a cognitive and institutional gap: while professionals understand and value the potential of GBS, systemic and operational challenges prevent consistent adoption. These findings support the call by Hamdouch and Depret (2010) for a more integrated policy frameworks that not only mandate green compliance but also offer financial and technical support during implementation. Moreover, the educational building sector presents a unique opportunity. Schools are long-term assets with high occupancy rates, making them ideal candidates for energy-efficient retrofitting.

7 Conclusion

The application of green building standards in retrofitting educational buildings in South Africa holds significant promise for improving energy efficiency, water conservation, and indoor environmental quality. However, the widespread adoption of these standards is hampered by financial, technical, and institutional barriers. To overcome these challenges, a more coordinated approach, supported by targeted policy interventions, capacity building, and public-private partnerships, is needed. By addressing these obstacles, South Africa can unlock the full potential of green building standards to create sustainable, resilient, and

healthy learning environments for future generations. It is recommended that the government incentivise green retrofitting through subsidies, grants, and tax incentives, making it more financially feasible for schools to pursue energy-efficient and water-conserving upgrades. Furthermore, aligning policies at the national, provincial, and local levels could help create a more supportive regulatory environment for green retrofitting. Collaboration between the public and private sectors could unlock additional funding and expertise for green retrofitting projects. Also, expanding training programs for school administrators, teachers, and local contractors on green building practices would build the necessary skills to implement and maintain retrofitting projects effectively.

Acknowledgement

We acknowledge the support of the Sustainable and Human Settlement Research Centre, University of Johannesburg, South Africa.

Funding

This research was funded by the University of Johannesburg, South Africa.

Ethical Approval Declaration

The study was conducted in accordance with established standards for research integrity and ethics.

Data Availability Statement

The participants of this study did not give written consent for their data to be shared publicly, so supporting data is not available due to the sensitive nature of the research.

Conflicts of Interest

The authors declare no conflict of interest.

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