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Embedding sustainability in architectural design: Insights from the Faculty of Engineering, Science & Technology (FEST)

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ABSTRACT *This research investigated the integration of sustainability principles into architectural design education at the Faculty of Engineering, Science, and Technology (FEST) of the Maldives National University. A qualitative and exploratory case study methodology was utilised, using document analysis, semi-structured interviews, and observations from design studios to investigate the perceptions and applications of sustainability in architecture education among academics and students. The results indicate that FEST has embraced a holistic approach to sustainability. The faculty uses a variety of teaching strategies, such as community-based learning, experiential learning, and interdisciplinary collaboration, addressing the theory-practice gap identified in previous research. These strategies help students develop critical competencies, including systems thinking, critical reflection, and strategic planning, that are necessary for addressing complex sustainability challenges in the Maldivian built environment. While the programme demonstrates progress in developing sustainability-conscious architects, challenges remain in translating educational ideals into professional practice, especially in relation to social sustainability. This case study provides insights into effective strategies for incorporating sustainability within architectural design education in island contexts facing urgent sustainability challenges.*

Key Words: Education for Sustainability, Architectural Design, Community-Based Learning, Experiential Learning, Interdisciplinary Collaboration

Introduction

Education for Sustainability (EfS) promotes holistic, transformational education that empowers learners to make informed decisions and take responsible actions for "environmental integrity, economic viability, and a just society for present and future generations while respecting cultural diversity" (UNESCO, 2018). Climate change, land degradation, and sea level rise are examples of sustainability challenges that go beyond ecological concerns; they also have social justice implications and are relevant to all disciplines (Sachs, 2015). EfS aims to address these issues by promoting sustainable behaviours. In this context, higher education institutions play a crucial role in tackling sustainability challenges through their educational programmes, research, operational practices, and community engagement (Ralph & Stubbs, 2014; Weber, 2012).

In recent years, there has been a greater emphasis on incorporating sustainability principles into architectural design education (Ceylan & Soygeniş, 2019; Goh et al., 2023; Iwuanyanwu et al., 2024). The built environment, which includes buildings, infrastructure, and urban spaces, has a significant impact on the natural environment.

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This impact arises from its role in the use of natural resources such as land, water, energy, and raw materials during construction and operation, resulting in significant waste and greenhouse gas emissions. Moreover, the design and functionality of the built environment influence how people interact with one another and with the environment (Holdsworth & Sandri, 2014). As a small island state vulnerable to the effects of climate change, the Maldives presents a compelling context for investigating architecture education's response to sustainability challenges.

This study examines the integration of sustainability in architectural design education at FEST, focusing on three key objectives: (i) investigate how academics and students conceptualise and implement sustainability principles within the architectural design curricula, (ii) analyse the pedagogical approaches and strategies used to develop sustainability competencies in architectural design students, (iii) examine how the integration of sustainability in FEST's architectural programme prepares students to address the unique challenges facing the Maldives as a small island developing state.

Literature Review

This literature review examines scholarly perspectives on the incorporation of sustainability into architectural education. It provides theoretical and contextual underpinnings for analysing these practices at FEST. The review begins by examining established theoretical frameworks, including the Triple Bottom Line, Sustainable Development Goals, Cradle to Cradle Design, and Ecological Modernisation Theory, which provide conceptual frameworks for analysing sustainability in architecture education. It then examines sustainability in traditional Maldivian architecture, followed by an exploration of the evolution of architectural education at FEST. Subsequently, the review synthesises research on sustainability competences, pedagogical approaches, and curricular integration strategies that inform effective education for sustainability in the built environment.

Frameworks for sustainability in architecture education

Several established theoretical frameworks provide conceptual lenses for analysing the integration of sustainability into architectural curricula. The Triple Bottom Line (TBL) framework, developed by Elkington (1997), defines sustainability as the intersection of environmental, social, and economic dimensions, emphasising that sustainable development must balance ecological integrity, social equity, and economic viability. In architectural education, the TBL framework informs curriculum design that addresses environmental protection, resource efficiency, social inclusivity, cultural appropriateness, and economic feasibility of design solutions (Klotz & Vasquez, 2011). This holistic approach is particularly relevant for small island contexts such as the Maldives, where sustainable architecture must address environmental vulnerability, social cohesion, and economic constraints.

The United Nations' Sustainable Development Goals (SDGs) provide a global framework for sustainability action across seventeen interconnected goals. Several SDGs are especially relevant in architecture education, including SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 12 (Responsible Consumption and Production). The SDG framework encourages architectural programmes to develop competencies that enable graduates to contribute to multiple sustainability goals through integrated design thinking. For

island nations facing existential climate threats, the SDGs provide an important framework for linking architectural education to broader national and global sustainability commitments.

The Cradle to Cradle (C2C) design philosophy developed by McDonough and Braungart (2002), critiques traditional linear 'cradle-to-grave' production models and advocates for closed-loop systems in which materials continuously cycle through technical or biological metabolisms. In architectural education, C2C principles inform pedagogy in material selection, life cycle thinking, waste management, and regenerative design strategies that aim not only to minimise harm but also to actively restore ecological systems (Zari & Hecht, 2020). This framework aligns with biomimicry approaches that seek to learn about the efficiency, resilience, and regenerative capabilities of natural systems.

According to the Ecological Modernisation Theory, environmental protection and economic development can be mutually reinforcing through technological innovation, market-based mechanisms, and institutional reforms (Mol & Sonnenfeld, 2000). This framework suggests that sustainability in architecture education should be viewed not as a constraint on development but as a driver for innovation, competitiveness, and quality. However, critics argue that ecological modernisation may prioritise technological solutions while underemphasising deeper social and cultural transformations required for sustainability (York & Rosa, 2003). For emerging economies and small island states, the tension between modernisation aspirations and ecological limits presents unique pedagogical challenges that architectural education must navigate.

Indigenous sustainability strategies in Maldivian vernacular architecture

According to Hameed (2024), a thorough understanding of sustainability in the built environment must extend beyond modern technological and economic imperatives to include cultural dimensions. Vernacular architecture offers a historical case study in climate-responsive design, demonstrating that sustainability is not merely a modern concept but a longstanding feature of the Maldivian heritage (Ahmed, 2020; Jameel & Yahaya, 2015). Traditional Maldivian houses, for example are built with locally obtained and renewable materials like coconut timber, coral stone, and palm thatch, exemplify resource efficiency and a minimal ecological footprint (Hameed, 2024; Ahmed, 2020).

Traditional homes in Maldives were designed with their elongated sides facing the north and south, minimising exposure to the intense heat from the rising and setting sun (Ahmed, 2020). The floors were raised a few metres above the ground on layers of stacked coral stones to protect the structure from dampness and moisture, a precursor to modern flood-resilience strategies (Hameed, 2024; Ahmed, 2020). Crucially, the walls, often made of finely woven coconut fronds or timber panelling, were designed with strategic, small apertures (Jameel & Yahaya, 2015). This technique ensured continuous cross-ventilation and air circulation but prevented water ingress, providing passive cooling and smoke extraction without mechanical means (Ahmed, 2020). Furthermore, the addition of shaded verandas on the northern and southern sides of the main house extended the living space and provided solar shading, contributing to a comfortable internal microclimate (Jameel & Yahaya, 2015).

The use of lightweight materials such as timber and thatch allowed for modular construction and adaptability (Ahmed, 2020). Structures were designed to be expandable to accommodate growing families and, by their nature, could be more easily repaired or replaced (Jameel & Yahaya, 2015). The use of biodegradable and locally available materials supported a circular material flow, offering invaluable, time-tested lessons in resource stewardship and resilience to the marine climate (Hameed, 2024; Jameel & Yahaya, 2015). Traditional house layouts incorporated a deliberate separation of functions to ensure hygiene and thermal comfort. The kitchen, storage, and open-air bathing area were all situated in separate, detached structures away from the main living quarters (Jameel & Yahaya, 2015). This separation served as a critical heat management strategy, preventing the heat generated by cooking from raising the temperature of the main house. It also functioned as a key hygiene and fire safety measure, protecting the predominantly combustible living spaces (Jameel & Yahaya, 2015).

Historical development of architectural programmes at FEST

A historical contextualisation of the architecture programme at FEST is necessary for situating the current study comprehensively. The development of this curriculum reflects broader socio-political changes in the Maldives, moving from a necessity for technical expertise to a mandate for climate-responsive, sustainable design. The formalisation of the programme was a crucial nation-building initiative aimed at localising expertise (MNU, 2011). The Bachelor of Architectural Design course was introduced at the then-Faculty of Engineering and Technology (FET) in 2011 (FEST, 2011). This initial structure was designed to train Maldivians, providing them with the fundamental design, technical, and management skills necessary to enter the growing construction and tourism sectors. The priority at this stage was on enhancing foundational skills and technical competency, enabling graduates to reduce the nation's reliance on expatriate professionals (MNU, n.d.). In 2013, the faculty's designation was broadened to the Faculty of Engineering, Science & Technology (FEST). This change was not merely administrative; the inclusion of 'Science' formalised a deeper interdisciplinary link, integrating environmental science, marine biology, and general scientific rigour into technical disciplines.

The evolution of the curriculum subsequently reflected the Maldives' growing visibility as a Small Island Developing State (SIDS) severely vulnerable to climate change. As the nation advocated for climate action on the global stage, the internal educational mandate evolved: the architect's role expanded from mere designer to essential resource steward and climate change adaptor. As such the three-year (six-semester) program was restructured to systematically embed sustainability. Core design studios (e.g., Architectural Design Project series) began to integrate explicit sustainability criteria, moving beyond functional and aesthetic concerns to include ecological performance and resource management (MNU, n.d.). The rapid urbanisation of islands like Male' and Hulhumale', alongside mounting challenges of waste management and coastal erosion, influenced the curriculum to adopt a greater focus on urban planning, local development, and sustainable resource use, thereby directly addressing immediate national concerns (MNU, n.d.). The inclusion of career paths like 'Sustainable Design Consultant' and the department's interest in 'Local tourism and economic Development' reflect this strategic alignment with the country's socio-economic goals (MNU, n.d.; Nizar,

2024).

Core competencies required for embedding sustainability in architectural design

Sustainability competencies, including knowledge, skills, values, and dispositions, are crucial for promoting sustainability action (Besong & Holland, 2015; Rieckmann, 2018). These include systems thinking, imagining future scenarios, strategic planning, collaborative decision-making, and integrated problem-solving (Rieckmann, 2018; Wiek et al., 2011). For example, systems thinking is essential for understanding the interrelationships between environmental, social, and economic dimensions of sustainability. While imagining future scenarios or anticipatory competence is critical for redirecting current unsustainable development trajectories towards a more sustainable path. Strategic competence is required in designing, implementing and evaluating sustainability policies and action plans involving different stakeholders and facilitating multiple perspectives (Wiek et al., 2011).

Transformative pedagogies in sustainable architecture

In the built environment, pedagogical approaches that promote individual and societal transformation toward sustainability are crucial for preparing future professionals to address complex environmental challenges. Research indicates that participatory teaching and learning methods, including inquiry-based learning, experiential learning, and project-based learning, are effective in architectural education. These methods engage students in real-world problem-solving and critical reflection on the environmental, social, and economic impacts of their design decisions (Almeida, 2020; Holdsworth & Sandri, 2014). Furthermore, studies highlight the benefits of student-centred approaches, such as peer tutoring, in enhancing learning outcomes in sustainable design education by promoting collaboration, deeper understanding, and reflective thinking (Andres et al., 2021).

Incorporating sustainability into architectural curricula

Altomonte et al. (2014) argue that effective sustainability education in architecture requires a pedagogical shift that encourages knowledge transfer between creative and technical disciplines. The design studio plays a significant role in this process, providing a platform for students to apply theoretical knowledge (Mohamed & Elias-Ozkan, 2019). However, research indicates a gap between current studio pedagogy and the development of sustainable design competence, necessitating innovative teaching methods and structured activities (Afroz, 2020; Mohamed & Elias-Ozkan, 2019; Mohamed & Ibrahim, 2024). To address this deficiency, researchers advocate for strategies such as design competitions, 3D modelling, and a holistic integration of sustainability concepts across the entire curriculum (Mohamed & Ibrahim, 2024).

According to Amador et al. (2015), higher education institutions face challenges in achieving sustainability due to the highly specialised nature of disciplines, which can hinder collaborative and interdisciplinary work. While EfS addresses challenges that transcend disciplinary boundaries, its adoption can be slow due to a perceived lack of relevance within certain disciplines (Christie et al., 2015). Reinforcing this perspective, Conte (2016) contends that profit-

driven development has weakened the architect's role, leading to decontextualised designs that neglect the environment and human needs. Scholars emphasise that developing critical thinkers in social sciences, arts, and humanities is essential for analysing and discussing sustainability from diverse perspectives (Weber, 2012). Furthermore, Khan et al. (2013) advocate to bridge this theory-practice gap in the current discourse, emphasising sustainability as an intrinsic architectural value.

Researchers advocate for integrating sustainability into the curriculum across multiple academic years rather than as standalone subjects (Hendawy et al., 2024). This enables students to develop a comprehensive understanding of sustainability principles progressively. Similarly, Park et al. (2024) highlight the importance of integrating EfS into landscape architecture programs, emphasising project-based and interdisciplinary learning. Several studies explore specific aspects of sustainability integration in architectural education and practice. For instance, Zari & Hecht (2020) highlight the role of biomimicry in creating built environments that mimic natural systems and processes. Literature also acknowledges implementation challenges. For example, in the UK, architecture programmes encounter institutional barriers that require innovative solutions (Oliveira et al., 2015). Similarly, Antonini et al. (2021) identify barriers to integrating sustainability and resilience, including ambiguous definitions and a disconnect between theory and practice. Studies show that Malaysian architecture students and graduates emphasise the value of interdisciplinary learning and practical experience for effective sustainability education, demonstrating that these difficulties are not isolated (Ismail & Siraj, n.d.).

The literature extends beyond technical considerations, acknowledging the influence of cultural and spiritual dimensions on sustainable design. For example, Muchlis et al. (2024) highlight how Islamic principles can meaningfully inform environmentally responsible architecture. This multifaceted approach to sustainability education directly addresses the needs of the construction industry, which increasingly demands graduates with comprehensive ecological knowledge (Almeida, 2020). Furthermore, research explores the potential of emerging technologies to enhance these educational efforts. For instance, AI integration has shown significant promise for advancing both energy efficiency and cultural heritage preservation in architectural education (Dwijendra et al., 2024). Meanwhile, active learning strategies and the use of building performance simulation tools have been proven to enhance students' critical thinking, problem-solving, and environmental consciousness while fostering technological proficiency and adaptability to evolving technologies (Kyropoulou, 2024). Current research emphasises that a comprehensive understanding of green building extends beyond technical expertise. Taneja & Kumar (2024) argue for a holistic approach is required to integrate social, cultural, and ethical dimensions alongside environmental and economic considerations.

Methodology

Research design

This study employed a qualitative and exploratory case study design to examine how academics and students understand and engage with sustainability in architectural design education at the FEST. An exploratory approach was appropriate for this

study, given the limited existing research on sustainability integration within architecture education in Maldives and the need to understand how sustainable principles are perceived, experienced, and applied within studio-based learning environments (Taylor et al., 2016). The case study focused on a bounded system (the architectural design programme at FEST), enabling in-depth description and analysis of sustainability education practices within a specific institutional context (Creswell, 2013; Merriam, 1998).

Data generation methods

Three complementary data generation methods were used to gain a rich, contextual understanding of how academics and students understand and engage with sustainability in architectural design education at the FEST.

Document analysis

A qualitative content analysis was conducted on curriculum materials and students' work to examine how sustainability principles are embedded in architectural pedagogy, design projects, and student learning outcomes. Documents analysed include outlines of subjects related to sustainable design (n= 8 subjects), student design portfolios (n=5 portfolios) and program learning outcomes. The selection criteria for documents included: (a) explicit mention of sustainability in course objectives or content, (b) relevance to architectural design studio pedagogy, and (c) availability and accessibility during the study period. Documents were systematically reviewed to identify sustainability-related learning objectives, content coverage, pedagogical approaches, and assessment criteria.

Semi-structured interviews

Interviews provided opportunities to explore academics' and students' understanding and interpretation of sustainability in architectural design and how they experienced its implementation in studio-based learning environments (Cohen et al., 2007). Purposive sampling was employed to select participants based on their involvement with courses that explicitly addressed sustainability during the study period. For academics, the selection criteria included having taught for three years. Final-year undergraduate students were selected to ensure they had sufficient exposure to the curriculum and could reflect on their educational experiences comprehensively. The sample included architectural design instructors (n=2), students enrolled in the architectural design programme (n=6), and the Dean of FEST (n=1). Interview questions explored participants' conceptualisations of sustainability, pedagogical approaches, institutional support, curriculum integration, and perceived barriers and enablers. Interviews were audio-recorded with consent and transcribed verbatim for analysis.

Design-studio observations

Two extended studio sessions were observed to explore how sustainability principles were integrated into architectural pedagogy and whether students had opportunities to develop sustainability competencies (Besong & Holland, 2015). Observations focused on studio critiques and feedback sessions, integration of sustainability concepts in design discussions, student-instructor interactions around sustainable design, and learning activities that promote sustainability competencies.

Data analysis

Data were analysed using a deductive coding approach informed by theoretical frameworks on sustainability in architectural education and Education for Sustainability (EfS) principles. The coding process proceeded as follows:

1. Initial code development: A preliminary coding framework was developed based on: literature on sustainability competencies in design education (Besong & Holland, 2015); dimensions of sustainability (environmental, social, economic, cultural); pedagogical approaches to sustainability education; and institutional and curricular factors influencing sustainability integration.

2. Code application and refinement: Interview transcripts, observation notes, and curriculum documents were systematically coded. During this process, descriptive labels were assigned to words, sentences, or paragraphs related to key aspects of sustainability in architectural design education. Codes were refined iteratively as new patterns emerged. Constant comparison was used to identify similarities and differences across data sources (Glaser & Strauss, 1967).

3. Thematic development: Codes were grouped into broader themes through an iterative process of analysis. Five overarching themes emerged that captured how sustainability is understood, integrated, and enacted in architectural design education at FEST.

Table 1. Coding Matrix

Overarching Theme	**Sub-themes**	**Example Codes**
1. Institutional and curricular integration of sustainability	• Policy and strategic priorities • Curriculum structure and organization • Integration mechanisms • Resource allocation	• Sustainability in strategic plans • Standalone vs. integrated courses • Course requirements Budget and infrastructure support
2. Sustainable design principles and community-based learning	• Environmental design principles • Community engagement • Real-world applications • Project-based learning	• Passive design strategies • Community partnerships • Design-build projects • Local context intergration
3. Interdisciplinary collaboration and innovative approaches	• Cross-disciplinary partnerships • Innovative pedagogies • Technology integration • Research initiatives	• Engineering-architecture collaboration • Studio-based innovations • Digital design tools • Faculty research projects
4. Cultural and social sustainability in architechture	• Traditional practices • Vernacular architecture • Social equity • Cultural preservation	• Maldivian building traditions • Climate-responsive design • Community participation • Heritage conservation
5. Active and collaborative learning strategies	• Student-centered pedagogy • Collaborative activities • Critical thinking development • Competency building	• Studio critiques • Group design projects • Problem-solving exercise • Systems thinking activities

Ethical considerations

Ethical approval was obtained from the University of Canterbury's Educational Research Human Ethics Committee and the MNU Research Ethics Committee (2018/54/ERHEC). Participants provided informed consent, and confidentiality was maintained through the use of pseudonyms. All data were stored securely and accessible only to the researcher.

Findings

The findings are organised into five key areas: institutional and curricular integration of sustainability; community-based learning initiatives that connect academic knowledge with real-world applications; interdisciplinary collaboration strategies for sustainable design; cultural and social sustainability considerations that broaden traditional environmental perspectives; and active collaborative learning strategies that enhance student engagement with sustainability concepts.

Embedding sustainability within FEST's institutional framework and curriculum

There is an institutional focus on integrating sustainability as a foundational pillar of the architectural design curriculum at FEST. The Bachelor of Architectural Design program embeds sustainability as a comprehensive approach, including environmental, social, cultural, and ethical considerations throughout the curriculum. As such, FEST emphasises practical strategies to tackle sustainability challenges, including climate change and resource scarcity. A content analysis of core subject outlines which includes Architectural Design Project 2 (ARC109), Architectural Design Project 4 (ARC207), and Environment & Culture 1 (ARC 111) Environment & Culture 4 (BES243) reveals a developmental progression. For instance, ARC109 which is a 15-credit foundational subject, contains no explicit sustainability content in its weekly schedule, though sustainability considerations are implicit in design evaluation criteria addressing "social, cultural, religious, economic, and technological factors" (FEST, 2020). Meanwhile. BES243, a 12-credit theory course dedicates 100 percent of curriculum to sustainability topics across 14 weeks, addressing ecological design, climate-responsive architecture, sustainable materials, landscape design, community planning, and critical examination of urban sustainability.

Meanwhile, ARC207, a 20-credit course, structures its entire curriculum around "Design for sustainability: remote area, community, and ecotourism projects," embedding sustainability within design practice and including a compulsory field trip to a remote atoll. Learning objectives show similar variation. BES243's six objectives explicitly address sustainability, including "to appreciate the philosophical, historical, scientific and socio-cultural dimensions and influences on environmental sustainability" and "to understand the conceptual implications of such dimensions and influences on the designed environment" (FEST, 2020). ARC207 includes seven objectives, two explicitly addressing sustainability: "To develop skills in applying sustainable cultural and environmental design principles and practices in a remote context" (FEST, 2020). ARC109's four learning objectives make no explicit reference to sustainability, focusing instead on design histories, resourcefulness, and information literacy. Assessment rubrics reveal varied approaches to valuing sustainability. ARC207 explicitly evaluates "quality

of design, integration of site, space and form, environment and community health" sending a clear signal that sustainability performance influences grades. BES243's criteria emphasise intellectual engagement and research depth without explicitly naming sustainability, though the entire course content addresses sustainability concepts. ARC109's criteria focus on process and technical skill, with sustainability potentially encompassed within "human factors" and "integration" emphases.

This pattern reveals both strengths and gaps. The progression from implicit (foundational level) to explicit (intermediate and advanced levels) allows students to develop design competencies before confronting sustainability complexity. However, the implicit nature of early-stage sustainability may result in variable attention depending on instructor emphasis. The combination of practice-based (ARC207) and theory-informed (BES243) approaches at Semester Level 4 provides conceptual depth and applied capability, while context-specific focus on Maldivian settings ensures locally grounded sustainability education.

Academics specialising in architecture noted a high level of engagement with sustainability in architecture and urban planning courses:

Our whole curriculum, all our teaching is actually based on sustainability (A6).

The architectural design programs aim to enhance people's quality of life by improving the built environment. Sustainable architecture considers energy-efficient building designs, such as heating, ventilation, and cooling systems, and the use of renewable energy and sustainable building materials, as well as waste management. The 'Architectural Design Project', which consists of six distinct modules, is a core subject of the program. One of the learning outcomes of the Architectural Design Project 4 is:

To develop skills in applying sustainable cultural and environmental design principles and practices in a remote context (FEST, 2020).

Students are required to undertake 'design projects' that focus on social, cultural, and environmental issues within the local community. The design projects incorporate the knowledge, skills and values acquired in different modules. Before beginning any design project, students conduct a site analysis in which they investigate the physical environment, including climate, natural vegetation, and aspects of the human environment such as historical land use patterns and existing social infrastructure. During the process, students learn how to design a space without impacting the natural environment. Site investigation and appraisal assignments require students to critically assess the environmental impact of design decisions, such as the consequences of removing trees, altering water bodies, or maximising floor area at the expense of natural features. These exercises promote sustainable design thinking by encouraging students to preserve site-specific elements and consider eco-friendly strategies like passive cooling and the use of natural fencing instead of concrete walls. Moreover, the integration of recycling practices and awareness of sustainability regulations within the project lifecycle educates students on making environmentally responsible choices. There is a critical understanding among students that sustainability is an essential criterion for evaluating the functionality and success of architectural projects:

The aspects of sustainability are the core of a design. So, we don't even consider

> *a building to be functional without the basic elements, which we think are the sustainable elements (S5).*

This view aligns with contemporary global trends in architecture that prioritise environmental sustainability. Traditional definitions of functionality in architecture often focus on factors such as structural integrity, aesthetic appeal and utility.

Application of sustainable design principles through community engagement

Students in the architectural design course participate in community-based learning as a pedagogical strategy. They are involved in finding solutions to some of the environmental, social and economic challenges facing the capital city, Male'. These include issues like limited urban space, poor waste management, traffic congestion and lack of green spaces. Through this engagement, students develop an understanding of the context in which their design solutions will be implemented.

As the following comments from an academic indicate, engaging with the wider community is a fundamental aspect of sustainability education for architectural design students:

> *Most of their projects would involve going to the community and learning from the community and coming back to the studio and designing, there (A6).*

In studio settings, students reflect on their interactions with the community and incorporate insights into their design concepts. This pedagogical approach illustrates a critical learning cycle where theoretical knowledge is directly applied to practical challenges. By involving students in community-related projects, the architectural design course not only equips them with technical skills but also nurtures a sense of social responsibility. During the 'design trips' to local islands, students learn about sustainability issues in those communities. For example, students studied about sustainability issues related to local tourism on the island of 'Maafushi', which is located in South Male' Atoll, about 27 kilometres from Male'. One student voiced concern about the negative environmental impacts of the rapid growth of tourist facilities on that island:

> *They are having huge towers of guest houses, but what's the carrying capacity of the water? What's the carrying capacity of that small patch of beach? What about the reef? (S5).*

This reflects a growing awareness of the need for a delicate balance between economic growth through tourism and the preservation of the fragile marine ecosystems of Maldives. Students also participated in a field trip to Thoddoo island, where they had to design a museum for the island. They conducted surveys and took measurements using state-of-the-art surveying tools and computer software. This hands-on experience allowed them to move beyond abstract ideas and engage directly with the community, physical environment and unique challenges of the island. This informed their design decisions, ensuring that the proposed museum would be both functional and culturally resonant. Through these design trips, students develop a holistic understanding of how architectural design can contribute to the preservation of cultural identity while meeting environmental and social sustainability goals.

Innovative pedagogies and interdisciplinary collaboration

FEST has initiated sustainability-focused projects where academics from architecture and civil engineering departments are collaborating with academics from environmental backgrounds. For instance, one academic discussed an initiative to use plastic bottles in the design of building structures:

> Even in the civil engineering programs we are trying that through something like waste bottles can be used to make structures. So, one of our lecturers did a study incorporating the plastic into concrete and finding the strength (A5).

This interdisciplinary approach is crucial for a small-island state like Maldives where resource limitations and waste management are pressing concerns. It could open possibilities for incorporating building designs that promote circular economy principles within the construction sector. Students believe that sustainable architecture involves minimizing cost and the carbon footprint of buildings. They learn to incorporate cost-effective materials, construction techniques, and building forms from the very beginning of the design process. As such, they are involved in designing buildings that are not only environmentally responsible but also economically viable:

> *Throughout the course, we design buildings to minimise the cost, after even constructing the house to maintain the cost, not just the building cost (S2).*

In 'Architectural Technologies', students learn sustainability principles such as diversity, interdependence, resource utilisation, and adaptability. These principles are applied to agriculture, transport systems, buildings and infrastructure. One student shared his learning experience in sustainable design:

> *For example, biomimicry is something that has been used in architecture, and we have learned how wasps build their nests, how they circulate the air and how we can take that and apply it to our designs (S6).*

This demonstrates an understanding of how natural systems achieve functionality, efficiency and adaptability. In addition, students discussed sustainable solutions such as adopting energy-efficient designs, reusing construction materials, and constructing rainwater storage facilities.

Socio-cultural sustainability in architectural education

In the architectural design course, students study 'Environment and Culture' modules in five consecutive semesters. This suggests a holistic approach, where students are engaged not only in finding technical solutions, but also in understanding the broader social, cultural and environmental context. A key learning outcome of the subject is:

> *To appreciate the philosophical, historical, scientific and socio-cultural dimensions and influences on environmental sustainability (FEST, 2020).*

In 'Environment and Culture', students learn about environmental aspects of sustainability and also about social and cultural sustainability, such as heritage conservation. One student made the following comment on the importance of cultural aspects of sustainability:

> *The identity of a place needs to be conserved. What does it mean to be Maldivian*

in terms of the built environment? So, it's not only the building, but also a part of the culture we are expressing (S1).

By considering culture as an integral part of sustainability, students can create spaces that resonate with the local community's history and values. When asked about the importance of incorporating social elements of sustainability in the built environment, one student made the following comment:

There are some modules where we learn to design for disabled people. We should apply these things so that they are also part of our community (S2).

This pedagogical emphasis on inclusivity is a critical step in addressing the social dimension of sustainability. However, the same student believed that the social aspects of sustainability are rarely taken into account when people do actual projects. This reflects a broader issue in the construction and design sectors, where economic considerations often dominate decision-making due to market pressures and budget constraints.

Implementing active and collaborative learning strategies

As far as sustainability pedagogy is concerned, collaborative learning is one strategy observed in architectural design classes. Observations of the architectural design class revealed that students were actively engaged in discussions, sharing ideas, and collaborating on projects and problem-solving tasks. Through collaboration, learners gain new perspectives, challenge their assumptions, and develop communication skills and teamwork. The observed classroom showcases positive aspects of constructivist pedagogies and some integration of sustainability content through design considerations. The lecturer's thorough feedback on students' design projects indicates a commitment to providing detailed guidance, which can enhance students' understanding and improvement in their work. One student stated that having real-life experiences helped them understand the concepts they are studying:

We don't stay in the classroom and decide everything. We see things, we observe things, we feel things, and so we understand it (S1).

This experiential approach fosters critical thinking and creativity as students are exposed to real-world complexities that cannot be fully captured through classroom interactions alone. Additionally, students identified group work, model making, peer critique and lecturers' feedback as useful learning experiences. Peer critique helps students to identify strengths and weaknesses in design solutions. Student-centred pedagogical approaches like peer learning and peer tutoring have been proven to increase students' motivation and enhance their performance and understanding of sustainable design (Andres et al., 2021). Students expressed strong dispositions and ability in engaging with EfS. This transformation in their disposition and ability resulted from student-centred, active and collaborative learning processes. Moreover, students of the built environment value approaches to sustainable education, such as discussions that allow for participatory and respectful learning experiences that respect different perspectives (Holdsworth & Sandri, 2014).

Problem-based learning (PBL) activities contribute towards students' sustainability competence development. PBL gives opportunities for students to

put sustainability knowledge into practice, especially strategic thinking competence (Birdman et al., 2021). Students incorporated sustainable solutions in their design projects, such as energy-efficient designs, re-use of building materials and building rainwater storage facilities:

> *We have even devised plans to regenerate the water lens of the island, and we have different water collecting methods and how to store it in all of our designs (S7).*

This includes designing roofs and surfaces optimised for rainwater harvesting and incorporating landscape designs that enable rainwater to infiltrate and replenish groundwater. This is important for the Maldives, as natural sources of freshwater are limited in our low-lying coral islands. The thin lens of groundwater in most islands is contaminated by saltwater intrusion, and a significant percentage of the population relies on rainwater for drinking (Ministry of Environment and Energy (2017). Residents of the capital, Male City, as well as 34 out of 188 inhabited islands, have access to desalinated seawater produced by diesel-powered desalination plants (Ministry of Environment and Energy (2017). Students are developing a design philosophy rooted in sustainability, which holds long-term implications for the Maldives. This mindset is crucial for tackling significant environmental challenges such as climate change, rising sea levels, and resource scarcity.

Fostering practical learning experiences and industry engagement is a key focus of architectural education at FEST, providing students with opportunities to apply their skills in real-world contexts and prepare for professional practise. For example, in 2022, 60 students from the architectural design course participated in a design competition, proposing new urban development plans and creating unique conceptual designs for public spaces in Hulhumale' city. This competition allowed students to apply their knowledge and skills in real-world scenarios. The proposed designs addressed physical, ecological, and social contexts while enhancing public interaction and engagement. Every semester, FEST hosts an exhibition to showcase the work of architecture and interior design students to the public and industry professionals. This exchange of ideas and feedback allows students to refine their design and communication skills before entering the workforce. Moreover, students are given opportunities to demonstrate their skills, enabling them to network within the industry and launch their professional careers after graduation.

Discussion

The findings of this study reveals that the FEST has achieved a significant degree of success in institutionalising sustainability principles within its architectural curricula. This discussion interprets the significance of these findings by relating them to established sustainability frameworks, contextualising them within the unique challenges of the Maldives as a Small Island Developing State (SIDS), and identifying areas for further pedagogical development.

A contextually grounded and holistic framework

As a paradigm of successful integration, FEST's strategy moves beyond superficial incorporation, establishing sustainability as an overarching philosophy that evolves progressively across the academic years, a model advocated for effective integration

(Hendawy et al., 2024). The integration of theory modules with practice-based studios instils both the knowledge and the application of sustainability principles, addressing the theory-practice gap commonly found in architecture education (Khan et al., 2013). Crucially, the curriculum's holistic nature, encompassing environmental, social, economic, and cultural dimensions, reflects the triple bottom line (TBL) and Sustainable Development Goals (SDG) frameworks. FEST integrates these global frameworks mainly through its 'Environment and Culture' modules. The focus on cultural sustainability is arguably the most significant aspect of the programme, setting it apart from curricula that concentrate on technical green building standards.

Bridging vernacular heritage with sustainability learning outcomes

Incorporating traditional Maldivian architecture serves as an effective pedagogical strategy for contextualising sustainability. The traditional vernacular architecture of the Maldives, a tradition often built upon local materials and low-impact construction, functions as a pre-modern sustainability model in a contemporary educational framework. By studying these practices, students develop a cultural and historical understanding that the pursuit of sustainability is not an imported requirement but a rediscovery and adaptation of indigenous knowledge. This approach aligns with calls to use cultural heritage as a resource for contemporary, climate-resilient design in SIDS.

Fostering competencies for island-specific challenges

The finding that the curriculum emphasises Community-Based Learning (CBL) and experiential approaches is a strategic necessity for the Maldivian context. Through practical projects like waste management in Male' or design contests in Hulhumale', CBL helps students bridge the gap between academia and the workplace by requiring them to consider the many aspects of island life, where social and resource constraints are linked to environmental issues. The emphasis on systems thinking illustrated by the student's reflection on the carrying capacity of Maafushi demonstrates the successful development of this key competency (Wiek et al., 2011). In a nation vulnerable to climate change, architects must think beyond single buildings to consider the entire island system: its water security, energy grid, and ecological health. Furthermore, interdisciplinary collaboration addresses the practical need for integrated problem-solving as a direct response to SIDS resource scarcity and waste disposal crises, moving towards principles of the circular economy.

Limitations and future directions

While the findings indicate significant progress in integrating sustainability into architectural education at FEST, several challenges and opportunities for future development emerge. The gap identified between educational aspirations for social sustainability and industry practice indicates a need for stronger connections between academia and the professional sector. Future initiatives could focus on engaging industry partners in curriculum development and providing students with more opportunities to influence professional practice through internships, collaborative projects, and continued education programs for practising architects.

While the findings demonstrate the integration of sustainability across various

dimensions of the curriculum, there is limited evidence of formal assessment of sustainability competencies. Future research should explore how sustainability competencies are assessed within higher education contexts, with particular attention to the development and implementation of explicit assessment frameworks. Such frameworks could enhance the effectiveness of sustainability education by providing clear guidance for both students and faculty and ensuring that learning outcomes align with the goals of sustainable development.

This research revealed a significant gap in formal pedagogical training among lecturers at the FEST. Most participating academics began their teaching careers without prior training in instructional or assessment methodologies specific to their discipline. This lack of structured pedagogical training was identified as a challenge to effective teaching and learning, particularly in technical fields like architecture, where diverse and practical teaching approaches are essential. This research emphasises the need for systematic and mandatory professional development, focused on teaching methodologies to be conducted annually.

While this study focused on an exploratory analysis of sustainability integration, a next step for subsequent research is to conduct a comparative benchmarking exercise. It is recommended that future studies compare MNU's architecture programme with well-established international standards and exemplary programmes that have integrated sustainability holistically. Frameworks such as the UNESCO-UIA Charter for Architectural Education, the RIBA (Royal Institute of British Architects) Sustainable Outcomes Guide, and LEED-accredited educational frameworks would provide standards for a comparative analysis. Such an analysis would not only illuminate specific areas for curriculum improvement but also help align local pedagogical strategies with global best practices in sustainability education, ensuring the programme remains competitive and comprehensive on an international scale.

Conclusion

The results of this study indicate that FEST has made significant progress in integrating sustainability principles into architecture education, utilising a variety of pedagogical approaches to promote critical sustainability competencies. The holistic approach to sustainability, which includes environmental, economic, social, and cultural dimensions, prepares students to address the challenges facing the built environment in the Maldives and beyond. The emphasis on community-based learning, experiential approaches, and interdisciplinary collaboration provides valuable opportunities for bridging the theory-practice gap identified in the literature. Through direct engagement with real-world sustainability challenges, FEST emphasises the development of critical thinking, systems thinking, and strategic competencies essential for promoting sustainability. By bringing together expertise from diverse fields, FEST creates opportunities for innovative sustainability solutions that address the unique challenges faced by Small Island Developing States, including the Maldives.

Declaration

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Zealand. Data collection was conducted following approval from the University of Canterbury's Educational Research Human Ethics Committee and the MNU Research Ethics Committee (2018/54/ERHEC).

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Conflict of Interest Statement

The author declares that there is no conflict of interest regarding the publication of this article.

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