

Meeting the Sustainability Emergency in Built Environment Curricula through Tripartite Pedagogy Quasi-Experimentation

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ABSTRACT

This study evaluates the effectiveness of a tripartite pedagogy framework integrating specialized tracks, optional minors, and experiential learning to enhance sustainability education in built environment curricula. Employing a mixed-methods quasi-experimental design, the research assessed 239 industrial training students in Enugu, Nigeria. Results from the t-test demonstrate significant improvements in sustainability knowledge post-intervention and high interest in optional sustainability courses. Repeated measures of ANOVA revealed substantial enhancements in students' ability to apply sustainability concepts over time. Qualitative data highlighted practical challenges in experiential learning, including resource constraints. The findings provide empirical support for the tripartite approach, extending previous research by quantifying impacts on practical skills development. This study contributes to the limited body of evidence on integrated sustainability education interventions in the Global South, demonstrating significant improvements in students' sustainability knowledge and application skills through a tripartite pedagogy framework. The findings highlight the potential of specialized tracks, optional minors, and experiential learning to bridge the gap between academic preparation and industry needs. It is recommended that educational institutions prioritize these integrative approaches and address resource constraints to enhance the effectiveness and scalability of sustainability education in built environment curricula.

Keywords: Building Research Establishment Environmental Assessment Methodology, Built environment curricula, Experiential learning, Optional minors, Specialized tracks, Sustainability competencies

INTRODUCTION

The built environment sector significantly impacts global environmental quality, resource consumption, and public health. Correspondingly, recent data from the [United Nations Environment Programme \(2022\)](#) highlights a worrying increase in building energy demand, rising by over 4% since 2020, driven by rapid urbanization. This escalating ecological footprint underscores the urgent need for a paradigm shift in built environment practices towards sustainability ([Agboola et al., 2024](#)). Sustainability in the built environment involves economically viable, environmentally responsible, and socially equitable approaches to design, construction, and operation. This includes green building, low-impact development, renewable energy integration, and transit-oriented development ([Durdyev et al., 2018](#)). While critics argue that sustainable practices are costly, proponents emphasize that the long-term benefits outweigh initial investments ([Ewurum et al., 2020](#)).

Thus, the urgency to mitigate environmental degradation, health impacts, and resource depletion, while

enhancing resilience, underscores the need for skilled professionals in sustainability. However, current educational programs inadequately prepare built environment professionals ([Ohueri, 2022](#)). For instance, a systematic review of 89 global university programs shows limited and uncoordinated integration of sustainability concepts, leaving graduates underprepared for key practices like retrofitting structures, performing energy audits, and engaging stakeholders ([Rajabifard et al., 2023](#)).

This disconnect between academic preparation and industry needs hampers the transition to sustainable practices. Compounding the situation, rapid technological advancements and evolving societal expectations further pressure educational institutions to update curricula systematically to include sustainability as a core competency ([Taneja et al., 2022](#)). In this respect, promising interventions comprise specialization tracks, optional minors in sustainability-related fields, and experiential learning opportunities ([Angelaki et al., 2024](#); [Hou et al., 2023](#); [Ribeiro et al., 2021](#)). [Ewurum et al. \(2024\)](#) argue that the effectiveness of these interventions is impeded by their focus on siloed rather than integrated

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reforms. This view further corroborates a 2021 report by the World Health Organization citing that this fragmented approach limits the mainstreaming of sustainability concepts, suggesting the need for multiple complementary approaches within an overarching framework (WHO, 2021).

Accordingly, we present a tripartite pedagogy framework that integrates specialization tracks, optional minors, and experiential learning to create a robust framework for sustainability education. Wright (2021) underscores the critical deficiency of empirical studies concerning the application and assessment of this framework, especially within the Global South, while highlighting the pivotal role of faculty readiness in its effective integration. In light of the foregoing, research on tripartite pedagogy experimentation is essential to address the sustainability emergency in built environment curricula. The findings may inform evidence-based curricular reforms, bridge the gap between academia and industry, as well as develop a workforce capable of managing a resource-efficient built environment with minimized environmental impact.

Accordingly, the study aims to evaluate the effectiveness of integrating optional minors, specialized courses, and experiential learning opportunities into built environment curricula to enhance sustainability education and preparedness among students. The objectives of the study are to assess the short-term impact of a 2-week specialized crash course on students' sustainability knowledge, ascertain student interest levels for post-specialization track optional courses in the built environment, and examine the practical impact of a 1-month experiential learning program on students' ability to apply sustainability concepts in real-world scenarios.

Review of related literature

The integration of specialization tracks in green building and sustainable development within built environment education is supported by foundational educational theories. The concept of "deep learning" emphasizes intensive engagement with specific knowledge domains, allowing students to develop robust and transferable skills (Liu et al., 2024). Specialization tracks enable students to focus on elective courses in sustainability, fostering a comprehensive understanding of sustainable construction project management (Kovačević, 2022). "Situated learning" theory suggests that learning is most effective in authentic, contextualized settings (Donaldson et al., 2020). Specialization tracks provide opportunities to apply sustainability concepts in real-world

projects, bridging the gap between theory and practice. Additionally, the "constructivist" approach highlights the active construction of knowledge through collaborative and problem-based activities, enabling students to engage with sustainability challenges and develop problem-solving skills (Mityr, 2021).

Studies emphasize the practical considerations for implementing specialization tracks in green building and sustainable development, such as ensuring faculty expertise and access to specialized facilities (Asfaw et al., 2022). Optional minors in sustainability-related fields are supported by educational theories like "elective" learning, allowing students to tailor their experiences to their interests and career goals. "Interdisciplinary" and "transdisciplinary" education, as noted by Scharoun et al. (2023), are essential for integrating these minors, promoting knowledge synthesis from diverse disciplines to address complex sustainability challenges. Implementing these minors also requires resources for specialized coursework, credit allocation, course sequencing, and evaluating impacts on student outcomes (Strumbos et al., 2018).

Elbaghdadi (2023) explains that "experiential learning theory" emphasizes knowledge construction through hands-on, contextualized learning. In sustainability-focused built environment curricula, this can be achieved through real-world projects, field trips, and internships. However, many firms do not fully adopt sustainability principles, highlighting the need for graduates with sustainable construction management skills to provide authentic learning settings. This approach aligns with "situated learning theory," which advocates for learning in real-world contexts. Implementing experiential learning requires industry partnerships (Olawumi & Chan, 2020), access to facilities and resources (Chagnon-Lessard et al., 2021), and integration into the broader curriculum (Fini et al., 2018).

Despite limited studies on specialization tracks in built environment sustainability education, literature shows promising results. Ribeiro et al. (2021) found that green building and sustainable development tracks enhance students' awareness, knowledge, and inclination towards sustainable practices, while Angelaki et al. (2024) noted increased engagement and curriculum relevance. Robust evidence supports experiential learning, showing that hands-on experiences, like design projects and internships, significantly improve knowledge, engagement, problem-solving skills, and application of sustainable practices (Hou et al., 2023; Ordaz et al., 2021). Evidence on optional minors is limited but promising,

enhancing student awareness, knowledge, and professional development satisfaction (Griesinger, 2023; Holison, 2023). However, the majority of existing research on these interventions predominantly focuses on programs in the Global North, with limited evidence regarding their application and impacts, as a tripartite, in the Global South.

MATERIALS AND METHODS

This study employed a mixed-methods quasi-experimental design to evaluate the effectiveness of a tripartite pedagogy framework for enhancing sustainability education in built environment curricula. A quasi-experimental design was chosen due to its suitability for educational research where randomization is not feasible, and its ability to establish causal relationships in real-world settings.

The study was conducted at the Institute of Management & Technology (IMT), Enugu, Nigeria, focusing on 58 Industrial Training students of Real Estate and 181 of Civil Engineering departments. This institution was selected due to its prominence in built environment education in the region and its willingness to implement curricular innovations. For the experiential learning component, partnerships were established with three firms in Enugu: Ezealigo Associates, Ezech Ezech & Co., and Onwudingo Construction Limited. These firms were chosen based on their engagement in sustainable construction practices and willingness to participate in the study. A randomly selected sample of 6 students were each sent to Ezealigo and Eze Ezech, while 29 students were sent to the various construction sites of Onwudingo Limited.

The Building Research Establishment Environmental Assessment Method (BREEAM) was utilized as the sustainability intervention framework for this study, due to its comprehensive approach to sustainability assessment, international recognition, and adaptability to various contexts. A multi-method approach to data collection was employed to address the study's objectives. For objective 1 (impact of specialized crash course), pre- and post-intervention knowledge tests were administered to measure changes in students' sustainability knowledge. Reflective journals were maintained by students throughout the course to capture qualitative insights into their learning experiences. Paired sample t-tests were conducted to compare pre- and post-intervention knowledge test scores, allowing for the assessment of significant changes in student knowledge (Kim, 2015).

Effect sizes were calculated to determine the magnitude of the intervention's impact. Qualitative data from reflective journals were analyzed using content analysis to identify key learning outcomes and experiences (Krippendorff, 2018).

For objective 2 (student interest levels), a Likert-scale questionnaire was administered to assess student interest in optional sustainability courses after undergoing specialized tracks. Descriptive statistics were used to analyze the Likert-scale data, including measures of central tendency and dispersion. This process also involved semi-structured interviews with a subset of students to gain deeper insights into their motivations and perceptions. For objective 3 (impact of experiential learning), a practical assessment was conducted before and after the experiential learning program to evaluate students' ability to apply sustainability concepts. Observational data was collected by researchers during the experiential learning activities, in addition to semi-structured interviews with industry partners to gather their perspectives on student performance and program effectiveness.

Paired sample t-tests were used to analyze the pre- and post-intervention practical assessment scores. However, given the complexity of real-world application, a repeated measures ANOVA was also conducted to account for potential time-dependent effects and individual differences in learning trajectories (Maxwell & Delaney, 2004). Qualitative data from observations and interviews were analyzed using grounded theory techniques to develop a theoretical understanding of how experiential learning impacts sustainability competencies (Charmaz, 2014). All statistical analyses were performed using SPSS version 27.0, with a significance level set at $p < 0.05$. Qualitative data analysis was facilitated by NVivo 12 software to ensure systematic coding and theme identification.

DISCUSSIONS

As per objective 1, the paired sample t-test results indicate a significant increase in sustainability knowledge post-intervention ($t(238) = 8.56, p < 0.01$). The large t-value and small p-value suggest strong evidence against the null hypothesis, and the Cohen's d value indicates a medium effect size. Examination of reflective journals revealed enhanced understanding and appreciation of sustainability concepts. Descriptive statistics in Figure 1 shows high student interest in optional sustainability courses after the specialized tracks intervention.

Results in Figure 1 indicate a higher-than-average interest level of built environment students concerning registering for optional minors on sustainability principles. Interviews indicated that students valued the relevance of these courses to their career aspirations and were mostly fascinated by the fresh impetus they offered. For objective 3, the repeated measures ANOVA results demonstrate significant improvements in students' ability to apply sustainability concepts over time [$F(2,236) = 15.43, p < 0.01$], while the partial eta squared (η^2) suggests a moderate effect size, implying that the intervention had a substantial practical impact on students' abilities. Figure 2 confirms the veracity of this result by providing descriptive statistics for each time point, showing a clear upward trend in mean scores and a decrease in standard deviation, suggesting both improvement and convergence in students' abilities over time.

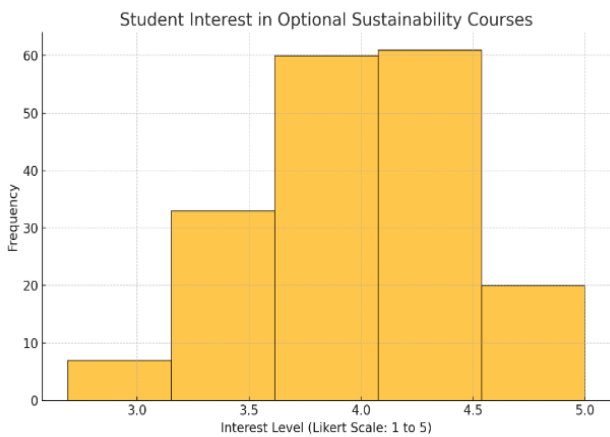


Figure 1: Interest levels in sustainability optional minors (Source: Field Survey, 2024).

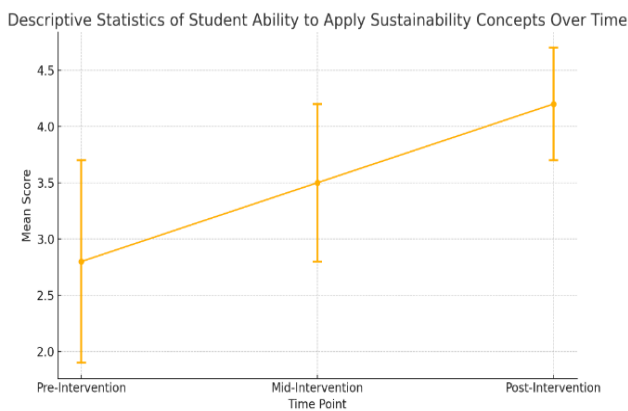


Figure 2: Effectiveness of experiential learning intervention (Source: Field Survey, 2024).

The graph (Figure 2) shows a clear upward trend in mean scores across the three time points, where pre-intervention had a mean score of around 2.8, mid-intervention had a mean score of around 3.4, and post-intervention with a mean score of around 4.2. This steady increase suggests a consistent improvement in students' abilities to apply sustainability concepts as they progress through the intervention. While the repeated measures ANOVA results confirm that these improvements are statistically significant, qualitative data highlighted practical challenges and learning outcomes, such as real-world constraints related to time, resource availability, and the limited access to sustainable materials and technologies posed significant hurdles.

The study's findings provide compelling evidence for the effectiveness of a tripartite pedagogy framework in enhancing sustainability education within built environment curricula. The significant increase in students' sustainability knowledge post-intervention ($t(238) = 8.56, p < 0.01$) aligns with previous research by Ribeiro et al. (2021) and Angelaki et al. (2024), confirming the value of specialized tracks in enhancing deeper understanding of sustainability concepts. The high interest levels in optional sustainability courses post-intervention (Figure 1) corroborate the findings of Griesinger (2023) and Holison (2023), suggesting that exposure to specialized tracks can indeed stimulate student engagement with sustainability-related fields. This outcome underscores the potential of optional minors as a complementary strategy within the tripartite framework. The repeated measures ANOVA results ($F(2, 236) = 15.43, p < 0.01$) demonstrating significant improvements in students' ability to apply sustainability concepts over time are particularly noteworthy. This finding extends the work of Hou et al. (2023) and Ordaz et al. (2021) by quantifying the impact of experiential learning on practical skills development. The moderate effect size (partial η^2) indicates a substantial practical impact, reinforcing the value of hands-on experiences in sustainability education. However, the qualitative data highlighting practical challenges such as time constraints, limited resources, and restricted access to sustainable materials reveal important limitations of the experiential learning component. These findings echo the concerns raised by Chagnon-Lessard et al. (2021) regarding the need for appropriate facilities and resources in implementing experiential learning opportunities.

Practical Insights

The study provides empirical support for the integration of specialized tracks, optional minors, and

experiential learning opportunities in built environment curricula. So, it is recommended that educational stakeholders should consider adopting this tripartite approach to enhance sustainability education by prioritizing faculty development programs to ensure instructors possess the necessary expertise to effectively deliver specialized courses and guide experiential learning activities. The identified practical challenges in experiential learning highlight the need for institutions to allocate adequate resources, including sustainable materials and technologies, to support effective implementation of hands-on learning experiences. Conversely, its success underscores the importance of developing strong partnerships between educational institutions and industry stakeholders engaged in sustainable practices.

Policy Insights

Policymakers and accreditation bodies should consider revising standards for built environment programs and incentivize industry participation in sustainability education initiatives to explicitly include sustainability competencies and experiential learning requirements. Government and educational funding bodies should prioritize resources for institutions implementing comprehensive sustainability education programs, particularly those incorporating experiential learning components. Professional bodies should consider developing sustainability certifications for built environment graduates, recognizing the specialized knowledge and skills acquired through programs implementing the tripartite pedagogy framework.

CONCLUSION

This study demonstrates that the tripartite pedagogy framework, integrating specialized tracks, optional minors, and experiential learning, significantly enhanced sustainability education in built environment curricula. The findings reveal notable improvements in students' sustainability knowledge, interest in optional sustainability courses, and practical application of sustainability concepts over time. These results accentuate the framework's efficacy in preparing students for sustainable practices, addressing the critical skills gap in the built environment sector.

Recommendations

Educational institutions should adopt the tripartite pedagogy framework to reform the built environment

curricula, with emphasis on faculty development, industry collaboration, and adequate resource allocation for experiential learning. Policymakers and accreditation bodies are encouraged to incorporate sustainability competencies and experiential learning as core standards to ensure graduates are equipped for sustainable practices in the built environment.

DECLARATIONS

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Authors' contribution

NIE: conceptualization (supporting), formal analysis (lead), investigation, methodology (lead), resources (lead), writing, analysis of the data obtained, and original draft (lead). NMA: conceptualization (lead), formal analysis (supporting), writing (review and editing), methodology (equal), validation (lead), supervision (lead). KK: Conceptualisation (supporting), formal analysis (supporting), investigation (supporting), methodology (supporting), validation (supporting), writing (review and editing: supporting). FIE: Investigation (supporting), methodology (supporting), supervision (lead), validation (lead), writing (review and editing: supporting).

Competing interests

The authors declare no competing interests in this research and publication.

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