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Empowering Educators: A Pilot Study of Faculty Training on Building Decarbonization and Clean Energy Integration

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Peter Rumsey, Stanford Building Decarbonization Learning Accelerator

Peter Rumsey is globally known for his 40-year leadership in the low energy and decarbonized buildings field. He has founded two success engineering design firms and worked globally. He has been a lecturer at Stanford University for over 10 years. He has given over 100 lectures about advanced and decarbonized buildings around the world, making him one of the foremost speakers on the topic.

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Abstract

This paper presents a pilot study evaluating a faculty training workshop focused on building decarbonization and clean energy education. Conducted at Stanford University through the Stanford Building Decarbonization Learning Accelerator (BDLA), the workshop engaged eight faculty members from Florida A&M University (FAMU) and South Carolina State University (SCSU). The primary aim of this pilot initiative was to enhance faculty expertise in sustainable energy, environmental justice, building decarbonization, and energy efficiency to integrate these topics into their curricula. The interdisciplinary workshop included participants from diverse fields such as electronics, architecture, construction, sustainability, and transportation, emphasizing a holistic approach to clean energy education. Faculty members were trained by top experts in the field, gaining insights into the latest research and practical applications related to decarbonization and renewable energy systems. This pilot study assessed the effectiveness of the workshop through post-surveys, measuring faculty preparedness, confidence, and their intent to incorporate clean energy concepts into their teaching. The findings indicate that targeted faculty training programs can significantly improve clean energy education delivery and interdisciplinary collaboration. Based on the outcomes, the study outlines plans for further curriculum development, faculty engagement, and expanding the program to benefit more students. Recommendations for scaling similar faculty development programs at other institutions are also discussed, contributing to the overall mission of preparing future leaders in the clean energy sector.

Keywords: Faculty Development, Clean Energy Education, Building Decarbonization, STEM Curriculum Enhancement, Sustainability Training

Introduction

The building sector, responsible for approximately 38% of global greenhouse gas emissions, is at the forefront of decarbonization efforts aimed at mitigating climate change [1]. As urbanization accelerates and energy demands rise, the need for innovative strategies to reduce emissions becomes increasingly urgent. These challenges extend beyond operational energy efficiency to encompass the full lifecycle of buildings, including materials, construction processes, and end-of-life considerations [2]. Simultaneously, the digital transformation of the design, planning, and construction industries is reshaping the approaches used to address these challenges [3]. Emerging digital tools, such as Building Information Modeling (BIM) and digital twins, are proving to be critical enablers in decarbonization efforts by integrating data-driven insights into sustainable design and construction practices [4, 5].

Higher education institutions (HEIs) have a pivotal role in this global transition. They are uniquely positioned to prepare the next generation of architects, engineers, and construction professionals by integrating decarbonization and digitalization into curricula. The dual objectives of these educational efforts are to address the technical challenges of reducing carbon emissions and to foster a new interdisciplinary skillset for navigating the increasingly interconnected nature of building systems [6, 7]. Faculty development programs, such as those focused on clean energy and sustainability education, are essential in achieving these goals by equipping educators with the knowledge and tools necessary to inspire and prepare students [8-10].

The growing emphasis on building decarbonization has led to initiatives like the Stanford Building Decarbonization Learning Accelerator (BDLA), which aims to empower faculty with cutting-edge resources to integrate sustainability topics into architecture, engineering, and construction courses [11]. These efforts align with broader global strategies, such as the European Union's Level(s) framework and the World Green Building Council Net Zero Carbon Buildings Commitment, to reduce the carbon footprint of the built environment [12, 13]. However, implementing these strategies at scale requires robust pedagogical frameworks, interdisciplinary collaboration, and practical training opportunities.

This paper examines the implementation and outcomes of a faculty development workshop designed to enhance educators' expertise in building decarbonization and clean energy integration. Conducted under the auspices of the BDLA, the workshop targeted faculty members from Florida A&M University (FAMU) and South Carolina State University (SCSU). It aimed to address the challenges posed by decarbonization and digitalization, equip faculty with tools and techniques for curriculum integration, and foster interdisciplinary collaboration.

Background and Literature Review

The Need for Faculty Development in Decarbonization Education

HEIs are increasingly recognized as pivotal in addressing global sustainability challenges, particularly in the context of decarbonization. The construction industry, responsible for a significant portion of global greenhouse gas emissions, is at the center of these efforts, necessitating educational interventions to prepare professionals equipped to meet these challenges [14, 15]. Faculty training programs aimed at integrating sustainability into curricula have demonstrated promise in enabling educators to teach emerging topics such as clean energy, building decarbonization, and energy efficiency [16, 17]. Despite the progress made, comprehensive training models for educators remain underdeveloped, particularly at Minority Serving Institutions (MSIs), which often face resource constraints. Rippy, et al. [16] highlighted the limited integration of sustainable construction practices into MSI curricula, emphasizing the need for targeted interventions to enhance teaching and learning. Faculty development programs like the BDLA address these gaps by providing expert-led workshops and practical resources, enabling educators to better integrate decarbonization topics into their teaching [17, 18].

However, MSIs continue to face distinct challenges that hinder their ability to integrate sustainability into curricula. Limited access to sustainability-focused funding restricts investments in faculty development, lab facilities, and curriculum innovation [19]. Additionally, MSIs often have fewer research collaborations and industry partnerships, reducing faculty exposure to emerging trends and best practices in decarbonization. Faculty at these institutions also carry heavier teaching loads, leaving little time for course redesign, research engagement, or professional development in clean energy education [20]. These structural constraints underscore the importance of targeted faculty training programs, collaborative networks, and dedicated funding opportunities to support sustainability education at MSIs. Without such support, faculty may struggle to introduce innovative pedagogies and sustainability-focused coursework, limiting student exposure to critical topics in building decarbonization [21]. Addressing these barriers through faculty development initiatives such as BDLA is a key step toward broader participation in clean energy education.

Digital Transformation in Sustainability Education

The digital transformation within the architecture, engineering, and construction (AEC) industries is driving significant advancements in sustainability education. Tools such as Building Information Modeling (BIM) and digital twins facilitate data-driven decision-making and lifecycle assessments, enabling stakeholders to optimize building performance and reduce environmental impacts [3, 4]. These technologies have proven instrumental in enhancing the integration of energy-efficient designs into construction projects [22]. Digital tools also support innovative pedagogical approaches such as Design-Based Research (DBR), which emphasizes iterative cycles of design, implementation, and evaluation [23]. These frameworks allow educators to refine their teaching practices based on real-world feedback, ensuring that sustainability education remains responsive to evolving industry needs [17]. The application of digital technologies within these frameworks has been shown to improve both teaching effectiveness and student outcomes, making them an essential component of modern sustainability education [24].

Interdisciplinary Collaboration and Pedagogical Innovation

Sustainability challenges require a systems-thinking approach that transcends traditional academic silos. Collaborative educational models that integrate architecture, engineering, and environmental sciences have been shown to effectively prepare students for addressing complex environmental issues [25, 26]. The European Union's UNI-SET program demonstrated the value of interdisciplinary master's programs designed to train professionals capable of leading multidisciplinary teams in sustainability-focused projects [27]. Project-based and problem-based learning methodologies are particularly effective in sustainability education, fostering critical thinking, collaboration, and real-world problem-solving skills [28, 29]. Faculty development initiatives that incorporate these pedagogical strategies, such as those offered by the BDLA, have significantly enhanced the ability of educators to deliver impactful and innovative courses [15, 18]. These approaches not only improve teaching practices but also better prepare students to navigate the complexities of the green building sector [24, 30].

Barriers and Opportunities in Decarbonization Education

While the integration of decarbonization into education offers clear benefits, several barriers persist. Limited institutional support, resource constraints, and the need for specialized faculty training are among the primary challenges, particularly at MSIs [16, 31]. However, these barriers present opportunities for innovative solutions. Faculty development workshops that leverage digital tools and interdisciplinary collaboration can serve as scalable models for broader implementation [24, 32]. The critical role of faculty development in advancing sustainability education cannot be overstated. By equipping educators with the tools, knowledge, and interdisciplinary strategies necessary to teach decarbonization effectively, HEIs can prepare the next generation of professionals to lead transformative efforts in the green building sector, driving environmental sustainability and systemic change [14, 23].

Methodology

This research adopts a Design-Based Research (DBR) framework, emphasizing iterative cycles of design, implementation, and evaluation to refine faculty training programs in sustainability education [23]. DBR is particularly suited for this type of educational research, as it aligns practical interventions with real-world application and continuous feedback, ensuring both relevance and adaptability. Social Cognitive Theory (SCT) also guides this study, focusing on observational learning and self-efficacy as critical components in faculty development [33]. By blending these theoretical frameworks, the study aims to explore the initial implementation of a faculty development workshop on clean energy integration, understanding its impact while identifying areas for improvement. This paper presents the pilot study of this ongoing research effort.

Objectives

The primary objective of this pilot study was to assess the effectiveness of the BDLA workshop in enhancing faculty expertise in decarbonization and clean energy integration. Specifically, this study sought to:

1. Assess changes in faculty preparedness, confidence, and intent to incorporate decarbonization concepts into their teaching practices following the workshop.
2. Explore the interdisciplinary collaboration fostered among faculty members from diverse academic fields during the workshop.

This initial study serves as a foundation for subsequent iterations of the faculty training program, enabling refinements based on participant feedback and observed outcomes.

Participants

The workshop brought together seven faculty members: six from FAMU and two from South SCSU. Representing a range of specializations—electronics and robotics, civil engineering, architecture, construction, sustainability, transportation, and hydrology—this group reflected the interdisciplinary nature of the program. This diversity was intentional, fostering cross-disciplinary dialogue and collaboration essential for addressing complex sustainability challenges.

Workshop Design and Activities

The BDLA faculty training workshop was held at Stanford University from August 5th to 8th, 2024. The program was designed to equip faculty with both theoretical knowledge and practical skills necessary to integrate clean energy and decarbonization topics into their teaching. The schedule of activities, detailed in **Figure 1**, included a balanced mix of lectures, hands-on activities, and site visits to provide a comprehensive learning experience. The workshop opened with sessions on the fundamentals of building decarbonization, including embodied carbon and lifecycle assessments. These theoretical sessions were complemented by interactive activities, such as exploring BIM for sustainable design and engaging in case studies on energy-efficient systems. Those activities were designed to engage participants in applied learning:

- Scenario-Based Learning in Low-Carbon Building Design: In a collaborative session, participants were divided into teams and presented with real-world case studies of low-carbon building projects. Each team was tasked with developing a decarbonization strategy for a hypothetical building, considering factors such as material selection, energy efficiency measures, and cost constraints. They then presented their strategies, receiving feedback from workshop facilitators and peers. This exercise encouraged interdisciplinary collaboration and critical thinking.
- Expert-Led Discussions and Case Study Breakdowns: Throughout the workshop, experts in sustainability and clean energy education facilitated discussions on successful decarbonization projects. These sessions focused on how faculty could integrate case studies into their own coursework by analyzing key challenges, solutions, and policy implications. Participants explored examples of net-zero energy buildings, district energy systems, and large-scale retrofitting projects, discussing how such models could be adapted into their curricula.

In addition to these interactive components, participants engaged in site visits to real-world examples of sustainable design, including the San Francisco Exploratorium, a net-zero energy facility, and the Exelixis Building, a model for net-zero carbon operations. These site visits reinforced the theoretical knowledge presented in earlier sessions, allowing faculty to see the implementation of energy-efficient systems in practice. In the afternoons, faculty attended specialized sessions tailored to their academic fields, covering topics such as lighting and daylighting design, HVAC systems, and sustainable building electrification. The inclusion of diverse academic disciplines, including architecture, construction, engineering, and sustainability, ensured an interdisciplinary approach to learning. Each day concluded with informal discussions during dinner, further encouraging collaboration and exchange of ideas among participants.

Pacific Times	August 4th	August 5th	August 6th	August 7th	August 8th
9:00:00 AM - noon		Welcome (Martin Fischer) Overview of Building Decarbonization (Peter Rumsey) Environmental Justice & Equitable Decarbonization (A. Kinslow/virtual)	Building Renewable Energy, Embodied Carbon, Case Studies (Peter Rumsey)	Tour Exelixis Building (net zero carbon) 9am-10am	Participants Depart
Lunch		Lunch on Campus	Lunch on Campus	Lunch on Campus	
1pm to 5pm	Participants Arrive Staying at Creekside Inn, Palo Alto	Building Energy Efficiency (Peter Rumsey) - Architecture - Lighting / Daylighting - HVAC Building Electrification (Peter Rumsey)	Tour SF Exploratorium (net zero energy) Visit Golden Gate Bridge	Decarbonization of Industry, Transportation and the Electrical Grid (Amory Lovins/virtual)	
Evening		Dinner in Palo Alto	Dinner in SF	Dinner in Palo Alto	

Figure 1. Schedule of the Decarbonization Workshop at BDLA

Data Collection Methods

To evaluate the workshop's effectiveness, data were collected using a combination of post-surveys and observational notes:

1. Post-Surveys: Participants completed post-workshop surveys to assess their knowledge, confidence, and intent to incorporate clean energy topics into their teaching. The surveys used a combination of Likert-scale items and open-ended questions to gather both quantitative and qualitative data.
2. Observational Notes: Facilitators documented observations during sessions, focusing on participant engagement, collaboration, and key discussion points.

Analysis Techniques

The data collected during the workshop were analyzed using a mixed-methods approach to provide a comprehensive understanding of its outcomes. This approach combined quantitative and qualitative techniques to evaluate the effectiveness of the BDLA workshop and its impact on faculty participants.

- Quantitative analysis focused on examining survey responses. Descriptive statistics were employed to summarize participants' pre- and post-workshop knowledge, satisfaction levels, confidence in applying workshop content, and perceptions of the relevance of the material to their teaching and research. Comparative analysis was conducted to assess changes in participants' self-reported knowledge ratings before and after the workshop. To explore relationships between key factors, a correlation analysis was performed, and a heat map was generated to visualize connections, such as the alignment between satisfaction and content relevance or the relationship between prior knowledge and post-workshop confidence.
- Qualitative data analysis concentrated on open-ended feedback collected from participants through surveys and observations during the workshop. Thematic analysis was used to identify recurring themes in participant responses, such as their most valued aspects of the workshop and suggestions for improvement. Prominent themes were visualized through word clouds, which highlighted the most frequently mentioned ideas and provided a snapshot of participant sentiments.

This mixed-methods approach ensured a well-rounded analysis of the workshop's outcomes. The combination of quantitative metrics and qualitative insights enabled the study to capture not only measurable changes in faculty knowledge and confidence but also deeper, context-rich understandings of their experiences and perceptions. This layered analysis aligns with the iterative nature of the DBR framework and lays the foundation for future iterations of faculty development programs in sustainability education.

Results and Analysis

Participant Demographics

The workshop engaged a diverse group of faculty members from FAMU and SCSU, representing a range of academic departments, including architecture, civil engineering, and construction engineering technology. This interdisciplinary representation ensured a broad spectrum of perspectives and expertise, which enhanced the collaborative and interactive nature of the discussions. As shown in **Figure 2**, 75% of participants were from FAMU, while 25% were from SCSU. Regarding departmental expertise, the largest group (37.5%) specialized in civil engineering, followed by equal representation (25%) from architecture and electronic engineering technology, and 12.5% from construction engineering technology. This distribution highlights the intentional diversity of the participant pool, which is critical for addressing the complex, interdisciplinary challenges of building decarbonization.

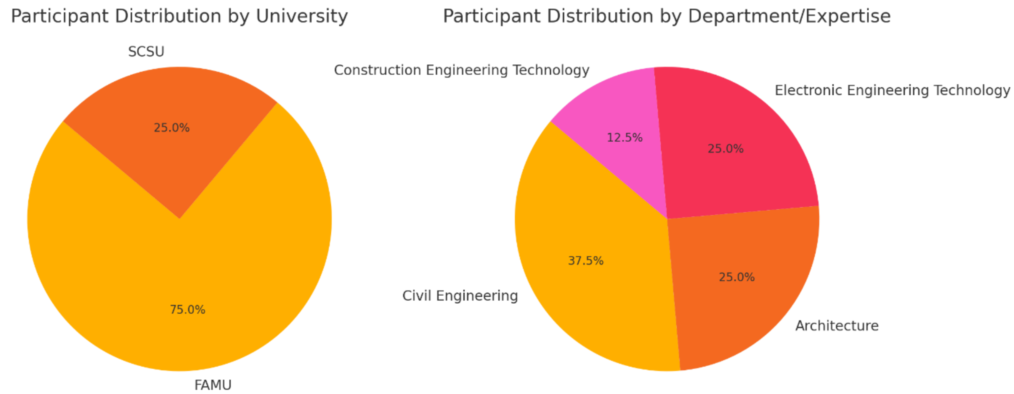

Figure 2: Participant Distribution by University and Department/Expertise.

Knowledge Assessment, Satisfaction and Confidence in Applying Workshop Content

Participants self-assessed their knowledge of building decarbonization before and after the workshop. The pre-workshop knowledge scores were relatively moderate, with an average rating of 2.9 out of 5, suggesting that many participants had limited prior exposure to the topic. Following the workshop, the average post-workshop knowledge rating increased significantly to 4.2 out of 5, demonstrating the workshop's effectiveness in enhancing faculty understanding of key concepts. This improvement is visually represented in **Figure 3**, which compares pre- and post-workshop knowledge ratings. While no formal statistical tests were applied in this pilot study due to the small sample size, the descriptive results indicate a positive trend. These findings suggest that targeted training programs like BDLA can significantly improve participants' understanding of complex sustainability topics.

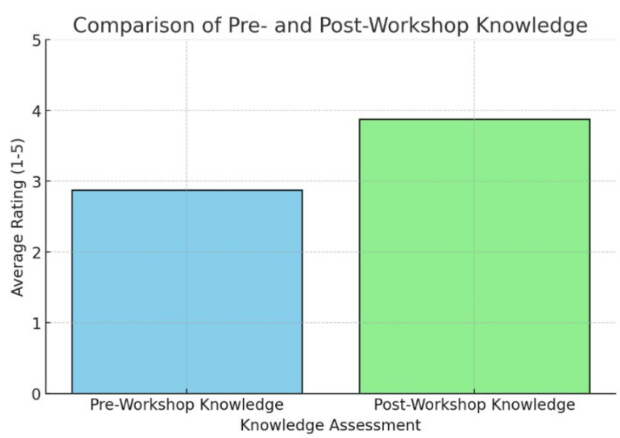

Figure 3: Bar chart comparing pre-workshop and post-workshop knowledge ratings.

The workshop was highly rated by participants, with all attendees giving a perfect satisfaction score of 5 out of 5. Similarly, the relevance of the workshop content to participants' teaching and research was rated at an average of 4.9 out of 5. These scores highlight the alignment of the workshop's goals with the professional needs of the participants.

Participants reported a high level of confidence in applying the knowledge gained from the workshop to their teaching and research activities. The average confidence rating was 4.5 out of

5, indicating that most faculty members felt well-prepared to integrate new concepts related to building decarbonization into their courses.

Analysis of Open-Ended Feedback

Qualitative feedback from participants provided valuable insights into the workshop's strengths and areas for improvement. The most liked aspects, as depicted in the word cloud in **Figure 4**, included hands-on activities, site visits, and the expertise of the instructors. These elements were praised for their practical relevance and ability to connect theoretical concepts to real-world applications. Suggestions for improvement focused on expanding the range of topics covered, particularly regarding low-carbon construction materials and diverse perspectives on decarbonization. Participants also expressed a desire for more time dedicated to interactive sessions and field visits.

Figures 4: Word Clouds for Most Liked Aspects and Suggestions for Improvement

Interest in Future Collaboration

The workshop fostered significant interest in future collaborative initiatives, with all participants expressing a willingness to engage in curriculum development or joint research projects. As shown in **Figure 5**, the highest levels of interest were observed among faculty specializing in civil engineering, followed by architecture and electronic engineering technology. These findings highlight the potential for interdisciplinary collaborations to emerge from the workshop, supporting the broader goal of integrating sustainability across academic disciplines.

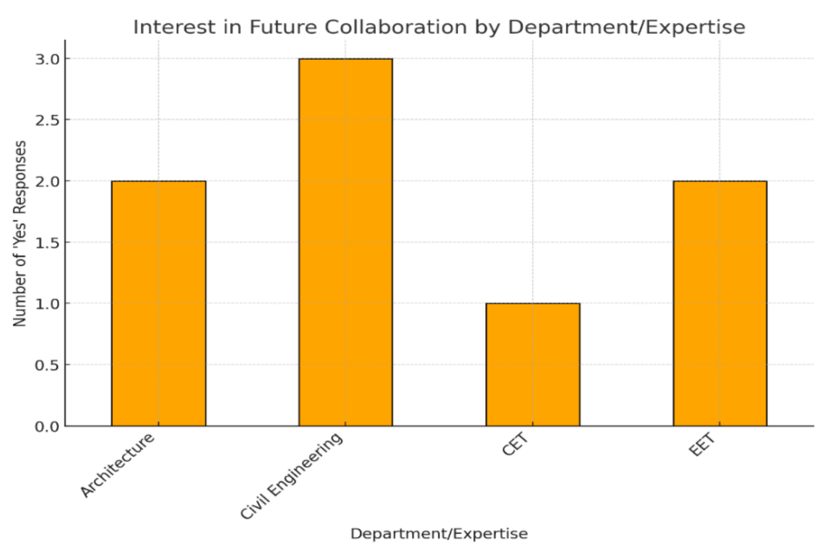

Figure 5: Bar Chart Showing Interest in Future Collaboration by Department/Expertise.

Correlation Analysis

A correlation analysis of survey responses revealed strong positive relationships between key factors. As shown in Figure 6, satisfaction with the workshop content was closely aligned with the perceived relevance of the material (correlation coefficient: 0.85). Additionally, higher pre-workshop knowledge was associated with increased confidence in applying the content, though the correlation was moderate (correlation coefficient: 0.65). These correlations provide further evidence of the workshop's effectiveness in addressing participant needs and building confidence in teaching and research applications.

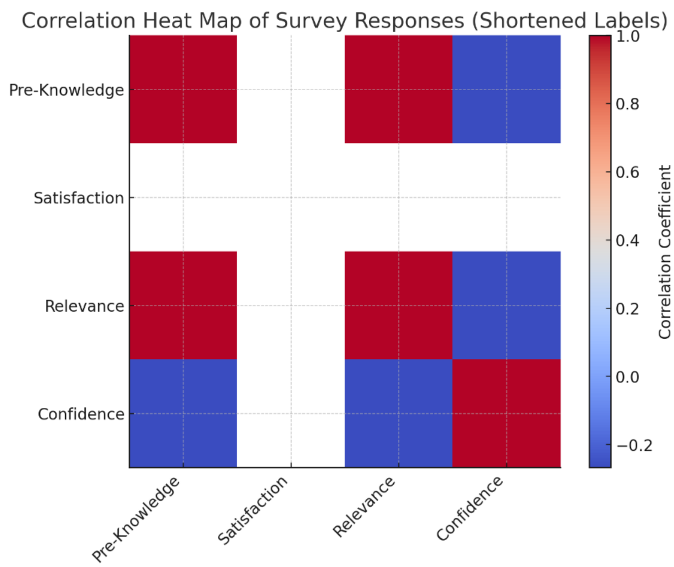

Figure 6: Correlation Heat Map of Key Survey Responses.

Discussion

The findings of this pilot study underscore the critical role that targeted faculty development programs play in advancing sustainability education, particularly at MSIs. The BDLA workshop effectively enhanced participants' knowledge, confidence, and intent to integrate clean energy topics into their curricula. The significant improvement in self-assessed knowledge scores, coupled with high satisfaction and relevance ratings, indicates that the workshop successfully met its objectives. The diversity of the participant pool contributed to the interdisciplinary nature of the workshop, fostering collaboration across academic fields. This interdisciplinary approach is essential for addressing the multifaceted challenges of building decarbonization, which require expertise spanning architecture, engineering, and sustainability. Furthermore, the integration of theoretical sessions with hands-on activities and site visits enabled participants to connect abstract concepts with practical applications, deepening their understanding of decarbonization strategies.

Challenges Faced by Faculty at MSIs

Participant feedback highlighted key institutional barriers that impact the ability of MSIs to integrate clean energy education into their curricula. One of the primary challenges raised was the lack of institutional funding dedicated to sustainability initiatives, which limits faculty access to specialized training and the incorporation of decarbonization tools in coursework. Several faculty members noted that while they were eager to integrate the concepts learned, their institutions lacked resources such as updated lab equipment, industry partnerships, and curriculum redesign support. As one participant commented, "Adding modules is possible, but without external funding, implementing hands-on components will be difficult." Additionally, participants expressed concerns about heavy teaching loads and limited time for course innovation. Unlike faculty at well-funded research institutions, educators at MSIs often teach multiple courses per semester with little time allocated for professional development or curriculum enhancement. Without institutional incentives—such as course release time or grant support—faculty may struggle to sustain long-term engagement in sustainability education.

Barriers for Historically Excluded Groups and Proposed Strategies

The workshop also revealed broader barriers affecting faculty from historically excluded groups. Faculty noted difficulty accessing specialized decarbonization training due to a lack of institutional prioritization. Unlike larger research institutions that have built-in sustainability initiatives, MSIs often do not have dedicated centers or programs for decarbonization research and education. This disparity reinforces the need for external collaborations, structured mentorship programs, and long-term partnerships with sustainability organizations like BDLA to provide continued training and support.

To overcome these barriers, several strategies should be considered:

- Establishing structured mentorship programs where experienced faculty from leading sustainability programs mentor MSI faculty in clean energy curriculum development and research.
- Forming long-term partnerships with organizations like BDLA to create sustainable professional development pipelines, ensuring continued faculty engagement beyond one-time workshops.
- Advocating for dedicated funding and institutional incentives, including competitive grants and travel funds to support faculty participation in clean energy training programs.
- Encouraging interdisciplinary faculty collaborations across institutions, allowing educators to pool resources, co-develop courses, and share best practices in sustainability education.

While the BDLA workshop was a significant first step in addressing these challenges, sustained engagement and institutional commitment will be necessary to ensure long-term integration of decarbonization education at MSIs. By addressing these barriers proactively, future iterations of the program can create more equitable access to sustainability training, empowering faculty to drive meaningful curriculum transformation at their institutions.

Conclusions and Recommendations

This pilot study highlights the effectiveness of the BDLA faculty training workshop in enhancing educators' knowledge, confidence, and intent to incorporate building decarbonization and clean energy topics into their teaching. By adopting a DBR framework and fostering interdisciplinary collaboration, the workshop addressed critical barriers in sustainability education at MSIs, equipping faculty with the tools and insights needed to prepare the next generation of professionals in the green building sector. While the outcomes are promising, this study represents an initial step in a larger research effort. Future iterations of the workshop should expand content to include emerging topics, such as low-carbon construction materials and advanced decarbonization technologies. Increasing the focus on hands-on activities and collaborative discussions, while extending the workshop's duration, would further enhance participant engagement and practical understanding. Longitudinal studies are also recommended to assess the long-term impact of the workshop on faculty teaching practices and student outcomes. Finally, developing scalable models for similar workshops at other institutions, particularly resource-limited MSIs, will help address equity in sustainability education and amplify the program's impact. These steps will ensure the continuous refinement and broader applicability of faculty development initiatives in sustainability education.

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