Integrating Climate Anxiety and Environmental Responsibility into Architectural Technology and Engineering Technology Curricula at an HBCU

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Abstract

Climate change presents not only technical challenges for the built environment but also significant psychological and ethical challenges for students preparing to enter architecture and construction-related professions. Increasing evidence of climate anxiety among young adults highlights the need for educational approaches that integrate technical competence with emotional resilience and professional responsibility. This study presents an ongoing pedagogical initiative at a historically Black university committed to social and environmental justice, examining how sustainability-integrated architectural technology instruction across multiple courses can reframe students' climate-related emotions while strengthening technical knowledge. The study draws on data from two undergraduate courses, ARC 2470: Introduction to the Technology of Architecture and ARC 3551: Architectural Structures II, in which sustainability and climate responsibility were embedded within core technical modules on building materials, structural systems, environmental systems, and building codes. Guided by constructivist and transformative learning theories, the instructional approach framed climate anxiety as a legitimate entry point for professional learning rather than a barrier. A mixed-methods pre- and post-course survey was administered to assess changes in students' self-reported technical knowledge, climate-related emotions, and perceptions of professional responsibility. Quantitative results indicate statistically significant gains in three of four technical domains, with large effect sizes observed for building materials, structural systems, and sustainability-related codes and regulations. Analysis of climate-related emotions reveals that while anxiety remained prevalent, feelings of powerlessness declined substantially, accompanied by marked increases in motivation and hope. Qualitative responses further suggest that students increasingly interpreted technical design decisions as ethical actions with environmental consequences. These findings suggest that sustainability-integrated technical instruction across multiple courses can transform climate anxiety into a sense of agency and purpose without diminishing awareness of the climate crisis. The study contributes a replicable, ethics-informed pedagogical model for architectural and engineering technology education and offers implications for curriculum design aimed at preparing students to address climate change through informed, responsible professional practice.

Keywords: climate anxiety, sustainability education, architectural technology, professional identity, HBCU, undergraduate education

Introduction

Climate change is increasingly recognized not only as a physical and ecological emergency, but also as a profound psychological, cultural, and social challenge [1], [2]. Rising global temperatures, sea-level rise, biodiversity loss, and intensifying extreme weather events pose urgent material risks to human and ecological systems [3]. Less visible, yet equally consequential, are the emotional and moral burdens of climate disruption on younger generations. A large international survey of young people published in The Lancet Planetary

Health found that more than 75% described the future as "frightening," over half reported persistent feelings of sadness, anger, or guilt, and many expressed diminished trust in governments and institutions to safeguard their futures [4]. These emotional responses, commonly referred to as climate anxiety, are not passive reactions but shape how students envision their futures, make life decisions, and form professional identities. These dynamics are particularly salient in architecture and construction-related education. The built environment is responsible for approximately 39% of global carbon emissions when operational energy use and embodied carbon in materials are considered together [5]. As a result, architects and allied professionals occupy a central role in climate mitigation and adaptation through decisions related to materials, structural systems, environmental technologies, and regulatory compliance [6]. Yet, while sustainability instruction in architectural education has expanded, it has traditionally emphasized performance metrics and technical optimization, often overlooking the affective dimensions of learning. When students' climate-related emotions are left unaddressed, sustainability risks being perceived as a technical add-on rather than a core professional ethic [7], [8]. Prior work in climate psychology suggests that acknowledging anxiety, when paired with opportunities for action, can foster constructive engagement and hope rather than paralysis [9].

This study examines how sustainability-integrated architectural technology instruction can simultaneously strengthen technical understanding and reframe climate-related emotions toward agency and responsibility. The study draws on data collected from two undergraduate courses at Florida Agricultural and Mechanical University (FAMU), a historically Black university with a strong institutional commitment to social and environmental justice: ARC 2470: Introduction to the Technology of Architecture and ARC 3551: Architectural Structures II. In both courses, sustainability and climate responsibility were embedded directly into core technical content related to building materials, structural systems, environmental systems, and building codes, rather than treated as supplemental topics. The instructional approach was informed by constructivist and transformative learning perspectives, framing climate anxiety as a legitimate entry point for professional learning rather than a barrier to technical mastery. Using a mixed-methods pre- and post-course survey, this study addresses three research questions:

(1) *Does sustainability-integrated technical instruction improve students' self-reported understanding of building systems, materials, and codes as they relate to sustainability?*
(2) *Does such instruction shift students' climate-related emotions from powerlessness toward motivation and agency? and*
(3) *How does integrating sustainability into technical coursework influence students' perceptions of professional responsibility and identity?*

By examining both cognitive and affective learning outcomes, this work contributes empirical evidence to ongoing discussions on climate pedagogy, architectural technology education, and the preparation of future professionals to engage meaningfully with the climate crisis.

Background and Related Work

Climate change is increasingly understood as a phenomenon that produces not only environmental and technical challenges, but also profound psychological and educational consequences. A growing body of research documents high levels of climate-related distress among young people, often described as climate anxiety or eco-anxiety [2], [4], [10]. Hickman et al. [4], in a large cross-national study of over 10,000 youth, found widespread fear, sadness, anger, and feelings of betrayal linked to perceived institutional inaction. Importantly, multiple scholars emphasize that climate anxiety should not be pathologized; rather, it represents a rational and adaptive response to real and ongoing environmental threats [2], [9], [10]. However, the educational implications of these emotional responses depend heavily on how learning environments acknowledge and engage them. Research in environmental psychology and education suggests that education can function as a critical mediator between climate anxiety and constructive action. Ojala [9] argues that young people require pedagogies that balance honest engagement with climate realities while fostering agency, meaning, and hope. When education focuses exclusively on catastrophic outcomes without pathways for action, it risks reinforcing helplessness and disengagement [11], [12]. Conversely, studies show that educational approaches emphasizing problem-solving, ethical responsibility, and collective efficacy can transform anxiety into motivation and pro-environmental engagement [13], [14]. Transformative and emancipatory pedagogies, in particular, have been associated with increased resilience, self-efficacy, and willingness to challenge unsustainable systems [15], [16].

These insights align closely with constructivist and transformative learning theories. Constructivist theory emphasizes that learners actively construct knowledge through interaction with prior experiences, values, and social contexts [17]. Transformative learning theory further suggests that education can prompt shifts in perspective when learners critically reflect on assumptions and reframe their understanding of complex societal issues [18]. Applied to climate education, these frameworks imply that technical knowledge gains are most impactful when integrated with reflective and value-oriented learning processes. Studies in sustainability education increasingly support this view, noting that deep learning occurs when cognitive, emotional, and ethical dimensions are addressed together [7], [19]. Within architectural and engineering education, sustainability instruction has expanded substantially over the past two decades, often emphasizing energy performance, materials efficiency, and life-cycle assessment [8]. Accrediting bodies such as the National Architectural Accrediting Board (NAAB) have formalized these expectations, particularly through criteria that emphasize technical knowledge related to environmental systems, materials, and performance evaluation. Despite this progress, several scholars note that sustainability is frequently positioned as a supplemental or specialized topic rather than a foundational professional ethic, especially within technically focused courses [8], [20], [21]. As a result, students may develop technical competence without a corresponding sense of agency or responsibility for addressing climate impacts through professional practice.

Recent critiques of architectural pedagogy further suggest that emotional dimensions of learning are often overlooked. While students are expected to master complex systems and calculations, little attention is paid to how climate awareness shapes their motivation, identity formation, and sense of professional purpose [22], [23]. This gap is significant given evidence that professional education plays a central role in shaping values, norms, and long-term identity [22]. Studies in engineering education similarly demonstrate that integrating ethical reflection and sustainability into technical coursework can strengthen students' sense of responsibility and preparedness for real-world challenges [24], [25]. Taken together, the literature indicates a clear need for pedagogical approaches that connect technical instruction with emotional engagement and professional identity development. Figure 1 presents the conceptual framework guiding this study, in which sustainability-integrated technical instruction mediates the relationship between pre-existing climate anxiety and the development of agency and responsibility. By embedding climate responsibility within architectural technology courses, this approach positions technical knowledge not only as a means of performance optimization but also as a tool for ethical action and professional empowerment.

Figure 1. Conceptual Reframing Model

Course Context and Pedagogical Intervention

This study was conducted within the architecture curriculum at FAMU, an HBCU with an institutional emphasis on equity, community engagement, and social responsibility. Data were collected from two undergraduate courses, *ARC 2470: Introduction to the Technology of Architecture* and *ARC 3551: Architectural Structures II*, which together span foundational and upper-division technical instruction. Examining these courses in parallel allowed the study to explore how sustainability-integrated pedagogy functions across different stages of students' academic and professional development. *ARC 2470* is a lower-division course introducing students to fundamental building technologies, including building envelopes, materials, environmental systems, and basic structural concepts. *ARC 3551*, an upper-division structures course, emphasizes structural behavior, load paths, material performance, and the relationship between structural systems and resource use. While the courses differ in technical depth, both were intentionally redesigned to embed sustainability and climate responsibility directly into core technical content rather than treating these topics as supplemental or elective.

The pedagogical intervention centered on reframing technical instruction as a mechanism for climate-responsive professional practice. In both courses, sustainability considerations were integrated into lectures, assignments, and discussions addressing conventional technical topics. For example, instruction on building materials explicitly incorporated embodied carbon, durability, and life-cycle considerations; structural systems were discussed in relation to material efficiency and resource optimization; environmental systems were framed through energy performance, daylighting strategies, and passive design principles; and building codes were examined as regulatory tools that shape sustainable outcomes. This approach aligned with the *NAAB SC.4 Technical Knowledge criterion*, while extending its scope to emphasize ethical responsibility and environmental impact. Importantly, climate responsibility was not introduced as an abstract or moral directive, but as a practical dimension of technical decision-making. Students were encouraged to view their technical choices as consequential interventions with measurable environmental outcomes. Class discussions explicitly acknowledged students' pre-existing concerns about climate change and framed technical knowledge as a means of addressing those concerns through professional action. This instructional framing reflects the conceptual model shown in Figure 1, in which sustainability-integrated technical instruction mediates between climate anxiety and the development of agency and responsibility.

To assess the impact of this pedagogical approach, a mixed-methods pre- and post-course survey was administered across both courses. The survey instrument included Likert-scale items measuring students' self-reported technical knowledge in sustainability-related domains, as well as items capturing climate-related emotions such as anxiety, motivation, and hope. Open-ended questions invited students to reflect on how course content influenced their perceptions of professional responsibility and their ability to contribute to climate solutions. While the surveys were administered separately in each course, data were analyzed collectively to identify broader trends associated with sustainability-integrated architectural technology instruction. By embedding sustainability within core technical coursework across multiple levels of instruction, this intervention sought to move beyond awareness-based climate education toward an applied, agency-oriented model. The following sections present the methodology for survey analysis and the resulting findings, focusing on changes in students' technical confidence, emotional orientation toward climate issues, and emerging professional identity.

Methodology

Research Design

This study employed a mixed-methods pre- and post-course survey design to examine changes in students' technical understanding, climate-related emotions, and perceptions of professional responsibility following sustainability-integrated architectural technology instruction. The design aligns with prior educational research that uses surveys to capture both cognitive and affective learning outcomes in engineering and sustainability education [14], [26], [27]. Quantitative survey items were complemented by open-ended reflective prompts to provide contextual insight into students' perceptions and experiences.

Participants and Course Context

Participants were undergraduate students enrolled in two architecture courses at Florida A&M University (FAMU): ARC 2470 (Introduction to the Technology of Architecture) and ARC 3551 (Architectural Structures II). ARC 2470 primarily serves lower-division students, while ARC 3551 enrolls upper-division students. Sustainability principles were intentionally embedded into core technical content in both courses. A total of 76 students completed the pre-course survey and 51 students completed the post-course survey. Because surveys were administered anonymously and could not be individually matched across time points, independent-samples statistical comparisons were conducted.

The respondent sample included approximately 43% female, 53% male, and 4% who preferred not to disclose gender. Academic levels included sophomores (31%), juniors (55%), freshmen (10%), and seniors (4%). These demographic patterns were generally consistent with overall enrollment in the participating courses during the semester. Demographic characteristics are summarized in Figure 2. Participation was voluntary and anonymous. Pre-course surveys were administered during the first two weeks of the semester, and post-course surveys were distributed during the final weeks of instruction. Because participation varied by time point and item completion, effective sample sizes differ slightly across measures and are reported where relevant in Section 5.

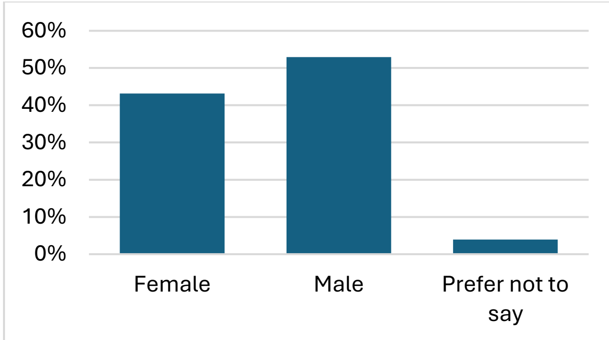

Figure 2. Gender Distribution of Participants

Survey Instrument

The survey instrument consisted of three primary components designed to capture technical learning outcomes, emotional responses to climate change, and evolving perceptions of professional responsibility. The full survey included demographic items (program, level of study, gender), structured response questions, and open-ended reflections. Representative items are included below for transparency. All surveys were administered online following Institutional Review Board approval (Project #074-25). Participation was voluntary and anonymous. No identifying information (e.g., names, student IDs, email addresses) was collected, and responses were reported only in aggregate form.

<u>1. Technical Knowledge Measures</u>: Students self-assessed changes in their understanding of sustainability-related technical domains using structured response items aligned with course learning objectives and accreditation expectations. Post-course items asked students to indicate how their understanding had changed relative to the beginning of the semester. These items correspond to the technical domains analyzed in Section 5. Example items included:

- *"How has your understanding of building materials' environmental impact changed?"* (Much less / No change / Slightly more / Significantly more)
- *"How has your understanding of structural systems' role in sustainability changed?"*
- *"How has your understanding of environmental systems (heating, cooling, daylighting) changed?"*
- *"How has your understanding of codes/regulations related to sustainability changed?"*

Students were also asked to rate perceived preparedness using items such as:

- *"To what extent do you now feel equipped to integrate sustainable strategies into architectural design?"* (Not at all equipped – Fully equipped)

<u>2. Climate-Related Emotional Measures</u>: Students reported changes in emotional orientation toward climate change using multiple-choice items adapted from climate psychology research [4]. Rather than diagnosing emotional states, the survey assessed shifts in self-perceived emotional stance over the semester. A representative item included:

- *"Compared to the beginning of the course, how have your feelings about climate change shifted?"* (Less anxious / About the same / More anxious / More motivated / More hopeful)

This structure allowed for capturing coexisting emotional responses, including anxiety, motivation, and hope. Emotional categories analyzed in Section 5 include anxiety or worry, feelings of powerlessness, motivation, and hope.

3. Professional Responsibility and Open-Ended Reflections: To examine identity formation and ethical framing, the survey included agreement-scale and open-ended prompts. Open-ended responses were used to identify themes related to agency, responsibility, reframed anxiety, and professional identity, as discussed in Section 5. For example:

- *"To what extent do you agree: I now see technical choices in architecture as ethical decisions with environmental consequences."*
- *"Looking forward, how do you plan to apply the lessons from this course in your academic or professional work?"*
- *"If you could suggest one improvement to this course to better prepare students for addressing climate change, what would it be?"*

Data Analysis

Quantitative data were analyzed using descriptive statistics and independent-samples t-tests to compare pre- and post-course responses across technical knowledge domains. Independent tests were used because responses were anonymous and not matched at the individual level. Effect sizes (Cohen's *d*) were calculated to assess the practical significance of observed differences. Emotional response data were summarized using percentage distributions to illustrate shifts in students' reported climate-related emotions. Qualitative responses were analyzed using thematic coding, focusing on recurring themes related to agency, responsibility, ethical awareness, and professional identity. Qualitative findings were used to support and contextualize quantitative results rather than to generate standalone claims.

Limitations

Several limitations should be noted. First, the study relies on self-reported measures, which may be influenced by response bias. Second, participation rates differed between pre- and post-course surveys, resulting in unequal sample sizes across time points. Third, data from two courses were aggregated to identify overall trends, which limits course-specific comparisons. Finally, the absence of a control group precludes causal inference; results should be interpreted as indicative of associations between sustainability-integrated instruction and observed learning outcomes. Despite these limitations, the methodology provides a practical and scalable approach for examining how architectural technology education can address both technical learning and climate-related emotional engagement.

Results

This section presents findings from the pre- and post-course surveys administered across ARC 2470 and ARC 3551. Results are organized into three areas: (1) changes in sustainability-oriented technical knowledge, (2) shifts in climate-related emotional responses, and (3) qualitative reflections on agency and professional responsibility. Quantitative results are presented first, followed by qualitative findings that contextualize statistical trends.

Changes in Sustainability-Oriented Technical Knowledge

Students reported increases in sustainability-related technical knowledge across all four assessed domains following course completion. Pre-course responses (n = 76) were compared to post-course responses (n = 51) using independent samples t-tests, as described in Section 3. Descriptive statistics, test results, and effect sizes are presented in Table 1, and visual comparisons of mean scores are shown in Figure 3. Statistically significant gains were observed in three domains:

- Building materials and sustainability ($p < .001$, $d = 0.77$)
- Structural systems and resource use ($p < .001$, $d = 0.97$)
- Sustainability-related codes and regulations ($p < .001$, $d = 1.22$)

Effect sizes ranged from large to very large, indicating educationally meaningful perceived growth in technical understanding. The strongest effect was observed for sustainability-related codes and regulations ($d = 1.22$), suggesting substantial increases in students' confidence navigating regulatory frameworks linked to environmental performance. In contrast, gains in environmental systems (e.g., HVAC and daylighting) were more modest ($p = .058$, $d = 0.33$). Although this change did not meet conventional statistical significance thresholds, the direction of change was positive and associated with a small-to-moderate effect size. As illustrated in Figure 3, this pattern suggests that while students perceived improvement in this domain, learning gains in environmental systems may require longer exposure or deeper technical integration. Importantly, these findings indicate that embedding sustainability within core technical domains, rather than treating it as an isolated topic, was associated with measurable increases in perceived technical competence.

Table 1. Pre- and Post-Course Technical Knowledge (t-tests, effect sizes)

Technical Domain	Pre-Course Mean (SD)	Post-Course Mean (SD)	*t*	*p*	Cohen's *d*
Environmental systems (HVAC, daylighting)	2.72 (1.24)	3.06 (0.73)	−1.91	.058	0.33
Building materials & sustainability	2.46 (1.18)	3.22 (0.73)	−4.45	< .001	0.77
Structural systems & resource use	2.24 (1.24)	3.22 (0.70)	−5.65	< .001	0.97
Codes & regulations related to sustainability	1.93 (1.11)	3.08 (0.72)	−7.05	< .001	1.22

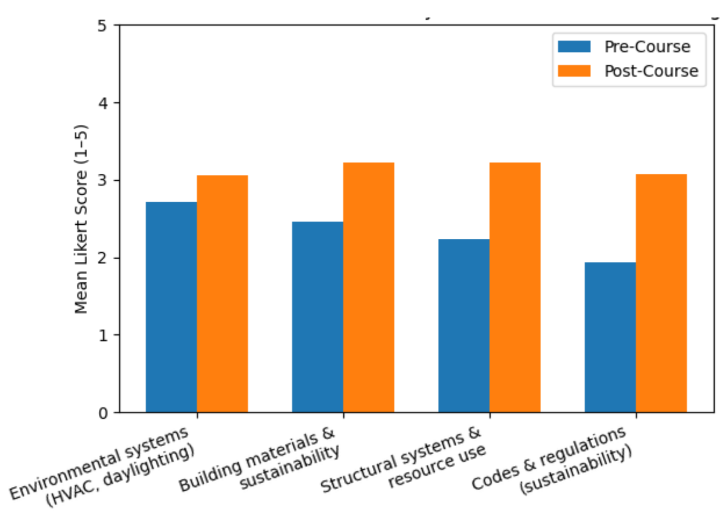

Figure 3. Pre-Post Technical Knowledge Gains

Shifts in Climate-Related Emotional Responses

In addition to technical outcomes, the study examined changes in students' emotional responses to climate change. Percentage distributions of reported emotions are presented in Figure 4. While climate-related anxiety remained prevalent, the proportion of students reporting feeling anxious or worried decreased slightly from pre-course (72%) to post-course (68%). More substantial change was observed in perceptions of agency: the percentage of students reporting feelings of powerlessness declined markedly from 55% to 22%. At the same time:

- Students reporting feeling motivated increased from 26% to 63%.
- Students reporting feeling hopeful increased from 18% to 41%.

These shifts indicate a notable reorientation in emotional stance over the duration of the courses. Importantly, anxiety did not disappear; rather, it coexisted with increased motivation and hope. This pattern aligns with climate psychology research suggesting that constructive engagement can develop even when concern remains high, provided students perceive viable pathways for action. Rather than eliminating climate anxiety, sustainability-integrated technical instruction appears associated with transforming passive concern into a more agentic orientation.

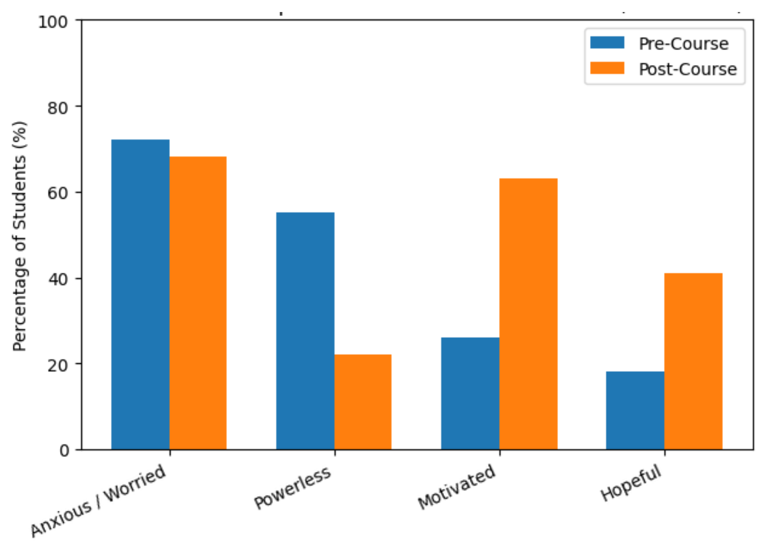

Figure 4. Shift in Climate-Related Emotions

Qualitative Reflections on Agency and Professional Responsibility

Open-ended survey responses provided further insight into how students interpreted their learning experiences. Thematic coding revealed three recurring themes: agency, professional responsibility, and reframed anxiety (summarized in Table 2). Many students described a growing awareness that technical decisions, particularly related to materials selection, structural efficiency, and regulatory compliance, carry environmental consequences. Several noted that sustainability shifted from an abstract ideal to a practical responsibility embedded in everyday design decisions. Students frequently referenced increased agency. For example, one student wrote:

"*Now I feel like I have tools to design better buildings.*"

Another reflected:

"*Technical choices are ethical choices.*"

Some responses indicated that anxiety persisted but became motivational rather than paralyzing:
"*I'm still anxious, but now it pushes me to think critically*."

These reflections support the conceptual model presented in Figure 1, in which sustainability-integrated technical instruction mediates between climate concern and professional responsibility. Importantly, several responses referenced students' evolving perceptions of their professional roles, suggesting that technical literacy may contribute not only to knowledge acquisition but also to identity formation within the discipline.

Table 2. Summary of Qualitative Themes with Representative Quotes.

Theme	Description	Representative Student Quote
Agency	Increased sense of ability to act through technical knowledge	"Now I feel like I have tools to design better buildings."
Responsibility	Reframing sustainability as an ethical obligation	"Technical choices are ethical choices."
Reframed Anxiety	Anxiety persists, but becomes motivating	"I'm still anxious, but now it pushes me to think critically."

Discussion

Technical Knowledge as a Site of Professional Agency

The strongest learning gains were observed in domains most closely tied to decision-making power within architectural practice, building materials, structural systems, and sustainability-related codes and regulations. These areas represent concrete points where technical choices have direct environmental consequences, including embodied carbon, resource efficiency, and regulatory compliance. The large effect sizes observed in these domains suggest that when sustainability is embedded within foundational technical instruction, students perceive meaningful growth in their capacity to engage climate-related challenges through professional action. In contrast, gains in environmental systems were more modest. This uneven distribution of outcomes may reflect differences in instructional time, system complexity, or prior exposure to mechanical systems. More importantly, the pattern suggests that not all technical knowledge contributes equally to students' sense of agency. Domains that clearly connect design decisions to measurable environmental outcomes may be particularly effective in reframing climate concern as actionable responsibility. These findings reinforce the study's conceptual model (Figure 1): sustainability-integrated technical instruction appears to function as a mediator between climate anxiety and professional agency. Rather than positioning sustainability as supplemental content, embedding it within technical domains central to architectural authority may support students in recognizing where they hold meaningful influence.

Emotional Shifts Without the Elimination of Anxiety

A central contribution of this study is the demonstration that positive emotional shifts can occur without eliminating climate anxiety. While reported anxiety remained high (72% pre-course; 68% post-course), substantial reductions in feelings of powerlessness (55% to 22%) and marked increases in motivation (26% to 63%) and hope (18% to 41%) were observed. This coexistence challenges deficit-oriented models of climate education that implicitly assume anxiety must be reduced before learning can occur. Instead, the findings align with climate psychology research suggesting that concern can be productive when paired with competence, meaning, and viable pathways for action. Students did not report becoming less aware of climate risks; rather, they reported feeling more capable of engaging them. From a pedagogical perspective, this suggests that architectural and engineering educators need not shield students from the emotional realities of climate change. Instead, technical curricula can intentionally engage these emotions by equipping students with actionable tools. In this framing, technical knowledge becomes a stabilizing force, helping students move from abstract fear toward informed engagement.

Professional Identity Formation

Reviewer feedback emphasized the importance of more explicitly connecting these findings to professional identity formation. Architectural education is not solely a process of skill acquisition; it is also a process of socialization into a professional culture. As Cuff (1991) argues, students internalize values, norms, and assumptions about what "counts" as architectural practice through curricular structure and emphasis. When sustainability is peripheral, students may implicitly learn that ecological responsibility is secondary to aesthetics or structural performance. In contrast, when sustainability is embedded within technical courses, materials, structures, and regulatory systems, it becomes normalized as part of professional competence. Several qualitative responses reflect this shift, particularly statements framing "technical choices as ethical choices." Such reflections suggest that students are beginning to see sustainability not as a specialization but as integral to their emerging professional identity. Importantly, this process unfolded across both lower- and upper-division courses. Early exposure in ARC 2470 appears to frame sustainability as foundational, while reinforcement in ARC 3551 deepens the connection between technical mastery and environmental responsibility. This staged integration may be particularly significant in shaping long-term identity formation.

Instructor Context and Pedagogical Climate

Because this study was conducted within two courses at a single institution, instructor style and classroom climate may have influenced student responses. Emotional engagement in learning environments is often shaped by faculty demeanor, ethical positioning, and facilitation style. It is possible that the observed shifts reflect not only curricular structure but also the way sustainability was communicated and modeled by instructors. Future research should examine how instructor affect, pedagogical framing, and classroom discourse practices interact with sustainability-integrated technical instruction. Multi-institutional studies would help disentangle curricular design effects from instructor-specific dynamics.

Demographic Considerations

The respondent sample included a relatively balanced gender distribution and representation across academic levels. While the present study did not disaggregate outcomes by gender or academic level due to sample size constraints, prior research suggests that environmental concern and professional identity development may vary across demographic groups. Future studies with larger samples should examine whether emotional shifts and perceived agency differ across gender identities, academic stages, or disciplinary tracks. Such analysis would support a more intersectional understanding of climate-responsive pedagogy.

Implications for Architectural and Engineering Education

The results have several implications for architectural and engineering technology education. First, sustainability should be embedded within core technical instruction rather than isolated within electives or theory-based courses. When sustainability is framed as integral to materials, structures, and regulatory systems, students are more likely to perceive it as central to professional responsibility. Second, affective learning outcomes deserve greater attention within engineering and technology curricula. Traditional assessments focus primarily on knowledge acquisition, yet this study suggests that emotional orientation, particularly perceptions of agency and responsibility, can shift meaningfully within technically focused courses. Third, sustainability-integrated instruction appears adaptable across stages of professional formation. Early coursework can introduce sustainability as foundational, while advanced courses can deepen technical complexity and ethical framing.

Broader Educational Significance

Beyond architectural education, these findings contribute to broader discussions in engineering and technology education regarding professional preparation for complex societal challenges. Climate change represents a "wicked problem" requiring technical competence, ethical reasoning, and emotional resilience. By positioning sustainability-integrated technical instruction as a mediator between climate anxiety and agency, this study supports pedagogical models that unify cognitive, emotional, and ethical dimensions of learning. Such models may be particularly relevant at institutions committed to social justice and community engagement, where professional education is closely linked to broader societal responsibility. Rather than eliminating climate anxiety, architectural and engineering education may play a constructive role in transforming it, equipping students not only with knowledge, but with the confidence and ethical grounding to act.

Conclusion and Future Work

This study examined how sustainability-integrated architectural technology instruction can influence students' technical learning, emotional engagement with climate change, and perceptions of professional responsibility. Drawing on data from two undergraduate courses at FAMU (ARC 2470 and ARC 3551), the findings suggest that embedding sustainability within core technical content is associated with meaningful gains in perceived technical competence and constructive shifts in climate-related emotional orientation. Rather than diminishing climate concern, the instructional approach appeared to support a transition from powerlessness (55% to 22%) toward increased motivation (26% to 63%) and hope (18% to 41%), reinforcing the role of technical knowledge as a foundation for professional agency. Importantly, the results suggest that technical instruction can function as a site of identity formation. When sustainability is embedded within materials, structural systems, environmental technologies, and regulatory frameworks, students begin to frame technical decisions as ethical decisions. In this way, architectural and engineering technology education can address climate change not only as a performance challenge, but as a formative professional responsibility. This reframing aligns with broader calls for educational models that integrate cognitive, emotional, and ethical dimensions of learning to prepare students for complex global challenges.

Several avenues for future research emerge from this work. First, disaggregating outcomes by course level, discipline, and demographic characteristics would provide a more nuanced understanding of how sustainability integration operates across contexts. Second, longitudinal research is needed to determine whether shifts in agency and professional identity persist beyond a single semester and influence later academic choices, design practices, or career trajectories. Third, multi-institutional or comparative designs could strengthen causal claims and help disentangle curricular structure from instructor-specific dynamics. Finally, extending this model across additional built-environment programs, including construction engineering technology and facilities management, would allow for broader assessment of its transferability. As climate change continues to reshape the professional landscape of architecture and engineering, educational approaches that connect technical competence with ethical responsibility and emotional resilience will be essential. Preparing students to act, rather than merely to understand, may be one of the most consequential contributions architectural and engineering education can make in this moment.

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