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Article

# Navigating Constraints: Advancing Sustainability Education Through Decentralized Governance and Applied Pedagogy

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## Abstract

Sustainability education in higher education is frequently framed through discrete pedagogical interventions or whole-institution approaches requiring strong central coordination. However, these models often align poorly with U.S. community colleges, where initiatives emerge under decentralized governance and institutional priorities centered on access and workforce preparation. In the absence of a national mandate for Sustainable Development Goals (SDGs), these institutions pursue sustainability education through voluntary, locally defined efforts. This study employs a qualitative case study approach to examine how sustainability education unfolds as a distributed, multi-initiative, and longitudinal process at Bronx Community College (BCC) of the City University of New York. The analysis covers diverse curricular and co-curricular spaces, including Life Cycle Assessment (LCA) coursework, climate science seminars, applied entrepreneurship initiatives, and the Associate of Applied Science (AAS) program in Entrepreneurship and Small Business Management (ESBM). Findings demonstrate that while sustainability education is organizationally dispersed, it achieves coherence when applied pedagogies recur across connected spaces and program-level pathways provide stable contexts for repeated student exposure. The study concludes by explaining how coherence is constructed under decentralization, clarifying the vital role of program-level structures in linking national policy non-alignment, system-level commitments, and local implementation. These results offer a scalable framework for integrating sustainability into vocational and technical education within decentralized academic systems.

**Keywords:** sustainability education; community colleges; life cycle assessment; higher education; decentralized governance; entrepreneurship; curriculum integration

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## 1. Introduction

Sustainability education literature identifies higher education institutions (HEIs) as central actors in addressing global sustainability challenges, emphasizing the interconnectedness of social, environmental, and economic systems [1–3]. Frameworks like the Triple Bottom Line and United Nations Sustainable Development Goals (SDGs) set expectations for education systems, with SDG 4 focusing on inclusive, equitable, and quality education [4]. Universities advance sustainability through curriculum integration, institutional practices, and societal engagement [5–7].

Labor markets and policy discourse increasingly require competencies such as systems thinking and applied problem-solving [8–10]. The impact of sustainability education depends on its enactment through teaching, learning, and institutional practice, rather than formal commitments [11–13]. Implementation is often uneven, limited to isolated courses or projects due to faculty capacity and institutional support [14,15]. Reviews show a growing range of SDG 4–aligned initiatives, but substantial variation in their conceptualization and implementation [16].

In the U.S., the absence of a national SDG mandate means sustainability education is pursued through decentralized governance—state systems and individual campuses—rather than coordinated mandates [17]. Large university systems, such as the City University of New York (CUNY) articulate sustainability strategies, but implementation remains local [18]. As a result, U.S. institutions lag behind their global peers in coordinated SDG investment and reporting, and sustainability education remains uneven [19–21].

Existing studies are fragmented, focusing on individual initiatives and short-term outcomes, with limited attention to how activities interact to produce longer-term effects [11–13]. Key gaps include under-specification of how decentralized contexts shape engagement with global frameworks, limited insight into how distributed initiatives accumulate institutional capacity, and a lack of longitudinal research on how sustainability education develops over time.

To address these gaps, this paper examines sustainability education as a distributed, multi-initiative, and longitudinal process within a decentralized governance context, guided by the following research questions.

**RQ1 (Governance and Context):** How does sustainability education emerge and develop within a decentralized U.S. higher education context, where engagement with global sustainability frameworks is voluntary rather than mandated?

**RQ2 (Institutional Integration):** How do multiple, distributed sustainability initiatives across a campus interact and build institutional capacity, rather than remaining isolated or initiative-centric?

**RQ3 (Longitudinal Institutional Process):** How does sustainability education evolve over time within an institution, and through what processes do early faculty-led initiatives enable subsequent curricular, co-curricular, and organizational practices that normalize sustainability without a formal mandate?

By analyzing the case of Bronx Community College, this paper demonstrates how early-stage efforts enable subsequent curricular and organizational practices. The remainder of the document is structured as follows: Section 2 reviews the literature; Section 3 presents the conceptual framework; Section 4 details the materials and methods used in the study; Section 5 analyzes the case study; Sections 6 discusses the findings; and Section 7 offers concluding remarks and future outlook.

## 2. Literature Review

Research shows sustainability integration in higher education is often fragmented, with isolated initiatives or elective coursework that rarely extend into core institutional practices [22,23]. Foundational studies highlight that embedding sustainability into daily institutional life—including operations and campus culture—improves educational outcomes [24,25]. The Whole-Institution Approach (WIA) is a key framework for embedding sustainability, emphasizing alignment between curricula and operations to support learning [26]. Misalignment between institutional practices and sustainability principles weakens educational impact, while alignment strengthens outcomes and reduces barriers [27].

Persistent gaps remain in the literature, particularly regarding the role of equity and social mobility, which often occupy a marginal position in sustainability discourse [28]. Scholars advocate for grounding sustainability education in the lived experiences of learners, thereby extending the pedagogical focus beyond classroom instruction to encompass campus culture, institutional governance, and community engagement [29–32]. This shift reframes sustainability education as a multifaceted institutional and social process rather than an isolated curricular intervention.

Competencies such as systems thinking, critical inquiry, and problem-solving are increasingly prioritized over content coverage [33–35]. Integrative pedagogies—experiential and problem-centered approaches—connect classroom learning with organizational and community contexts, as traditional lectures are insufficient for addressing sustainability's interdependencies [12,36–38].

Institutions have adopted mechanisms like sustainability offices, councils, and communities of practice to coordinate initiatives and reduce reliance on individual champions, as rigid departmental arrangements impede interdisciplinary sustainability education [39,40]. The Higher Education

Sustainability Initiative Partnership Framework of the United Nations Department of Economic and Social Affairs emphasize cross-functional collaboration [41]. These arrangements underpin “Campus as a Living Lab” models, where infrastructure serves as a pedagogical resource and requires formal coordination and data-sharing to support experiential learning [27,42].

Deeper structural assumptions are also examined. The Tripartite Structure of Sustainability (TSS) highlights the “inner-outer gap” between knowledge acquisition and behavioral change, emphasizing internal transformation alongside technical competence [43]. Sustainability education thus integrates reflective and experiential learning with technical skills for sustained change.

### 2.1. Community Colleges as Sustainability Infrastructure

Community colleges in the United States are a distinctive, often underexamined segment of higher education, positioned at the intersection of local economies, workforce development, and community needs. Their open-access mission enables participation by learners underrepresented in green-economy pathways, while their local embeddedness supports community-level climate adaptation and resilience initiatives [44,45].

Sustainability education and climate-aligned workforce development are increasingly pursued through applied models across institutional types. Four-year and graduate institutions have implemented experiential learning structures—such as consulting projects, labs, practicums, and capstones—to develop sustainability competencies and engage students with real-world challenges [46–51].

In parallel, community colleges offer a wide range of sustainability and green-economy programs in renewable energy, energy efficiency, sustainable agriculture, environmental compliance, transportation electrification, and green business, often through employer partnerships (Table 1). While these initiatives demonstrate breadth and workforce relevance, they are typically organized around discrete credentials or occupational pathways rather than integrated institutional models.

National studies using the AIREA Data Explorer document the expansion of green-aligned workforce pathways, while also highlighting regional and demographic disparities that raise equity concerns [52,53]. Despite this growth, a critical distinction remains between the proliferation of credentials and the development of integrated institutional architectures. Many initiatives persist as fragmented, parallel efforts, limiting their capacity to connect sustainability strategy with scalable pedagogy and workforce preparation [54].

This distinction motivates the present study. Rather than advancing an idealized model, this study examines how sustainability education is organized and enacted within a community college characterized by multiple, distributed initiatives. Table 1 summarizes representative community college programs and credentials aligned with sustainability and green-economy priorities, illustrating both programmatic breadth and emphasis on workforce relevance and external partnerships.

**Table 1.** Representative Community College Sustainability and Green-Economy Initiatives.

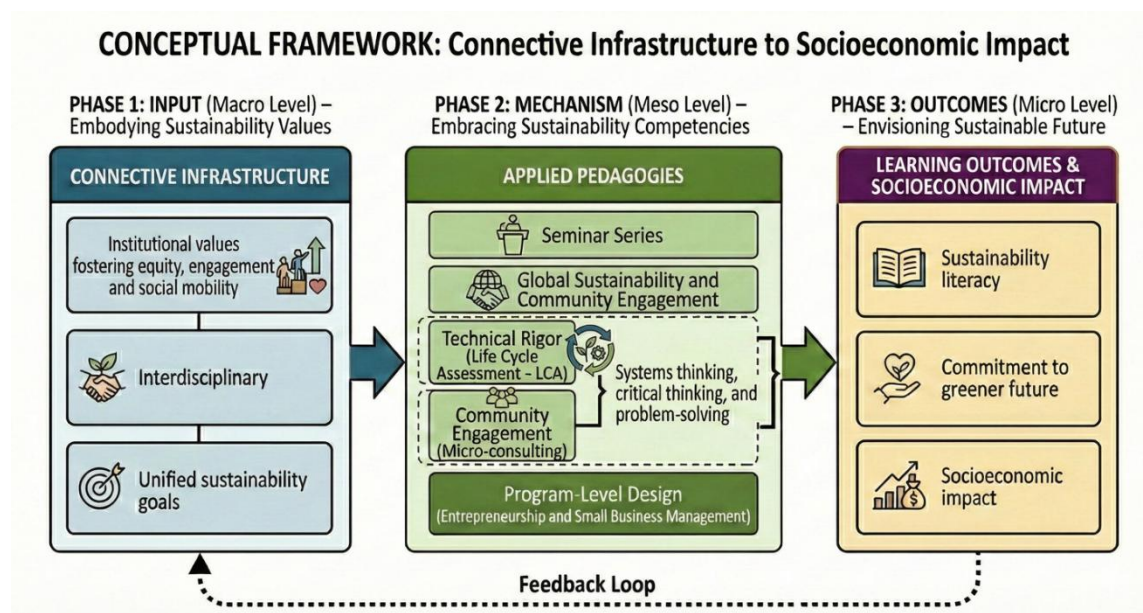
Program Category	Typical Focus Areas	Common Offered	Credentials	Example Institutions
Renewable / Clean Energy	Solar PV, wind basics, renewable systems, hands-on labs	NABCEP PV Associate; Institutional certificates	AAS	Northampton CC [55]; Madison Area Technical College [56]
Sustainability Technologies	Solar installation, energy management	Certificates; Sustainability Technologies	AAS	Central Piedmont CC [57]
Energy Efficiency	Weatherization, building science, energy auditing	BPI; HVAC certificates	Energy Auditor; automation	Bronx Community College; Laney College [58,59]

<b>Sustainable Agriculture</b>	Soil health, ecological stewardship, sustainable farming	AAS in Sustainable Agriculture; certificates	Central Carolina CC [60]
<b>Environmental Tech</b>	Monitoring, pollution control, remediation	Environmental Technician Certificate; AAS	Northern Essex CC [61]
<b>Green Business</b>	Sustainable operations, circular economy, ESG	A.S./B.A.S. in Sustainability Management	St. Petersburg College [62]
<b>Transportation Electrification</b>	EV maintenance, charging systems	EV certificates; ASE-aligned training	Rio Hondo College [63]
<b>HVAC Efficiency</b>	HVAC systems, refrigerants, efficiency	EPA Section 608; HVAC Technician certificates	Austin CC [64]; Wake Tech [65]
<b>Cross-Disciplinary</b>	Sustainability-designated coursework, ethics	Sustainability concentration (A.A. add-on)	Cascadia College [66]

### 3. Conceptual Framework

To address existing gaps in sustainability education literature, this study advances a multi-phase conceptual framework explaining sustainability education as a distributed, multi-initiative, and longitudinal institutional process within decentralized governance. Rather than viewing sustainability education as a discrete intervention, the framework conceptualizes it as an institutional system where values, structures, pedagogies, and outcomes interact over time.

As illustrated in Figure 1, the framework is structured as a logic model with three interrelated phases—Input (Connective Infrastructure), Mechanism (Applied Pedagogies), and Outcomes (Socioeconomic Goals)—linked by a feedback loop. These phases explain how macro-level institutional values are translated into micro-level learning and socioeconomic outcomes through program-level design and sustained practice.



**Figure 1.** The conceptual framework illustrating how institutional connective infrastructure and applied pedagogies interact over time to drive sustainability learning outcomes and socioeconomic mobility within a decentralized governance context. (Figure created with Google Gemini).

**(a) Phase 1: Input — Connective Infrastructure**

This phase focuses on the institutional infrastructure that enables sustainability education in decentralized systems. It is grounded in values of equity, social mobility, economic opportunity, and environmental sustainability. Interdisciplinary curricular structures move beyond departmental silos, supporting collaboration and integration into applied and professional programs. In community colleges, this infrastructure is crucial for linking sustainability education to workforce development and socioeconomic mobility. Program-level coordination aligns goals, curricular pathways, and assessment, translating values into operational coherence.

**Proposition 1:** In decentralized systems, sustainability education achieves coherence when program-level structures align values, curricula, and practices.

**(b) Phase 2: Mechanism — Applied Pedagogies**

This phase explains how sustainability education is enacted through applied pedagogies that develop competencies like systems thinking, critical inquiry, and problem-solving. These pedagogies connect conceptual learning to real-world application, enabling students to address sustainability challenges. Technical rigor and community engagement are complementary: analytic approaches allow systematic assessment, while community contexts ground learning in lived realities. Program-level anchoring provides coherence, while seminars, global linkages, and innovation spaces extend learning beyond formal curricula.

**Proposition 2:** Applied pedagogies across program and co-curricular spaces are more likely to build institutional capacity than remain fragmented.

**(c) Phase 3: Outcomes — Socioeconomic Goals**

This phase focuses on outcomes such as sustainability literacy, workforce readiness, and socioeconomic mobility. Students learn to apply sustainability concepts in professional and community settings. In community colleges, these outcomes are closely tied to economic opportunity. Rather than endpoints, outcomes reinforce institutional values and support ongoing investment in sustainability education.

**Proposition 3:** Over time, sustainability education becomes normalized as outcomes reinforce values and routinize practices.

**(d) The Feedback Loop**

The framework's feedback loop links student outcomes back to institutional inputs. Outcomes like employability and demonstrated competence reinforce values and support continued investment, allowing experimental initiatives to become stabilized within institutional practice.

## 4. Materials and Methods

This study uses a qualitative single-case approach, supported by descriptive statistics, to examine how sustainability initiatives are structured and enacted within a community college. The analysis spans curricular, co-curricular, and programmatic spaces in a decentralized institutional setting.

A case-based design is appropriate for sustainability education contexts where initiatives span multiple programs, partnerships, and organizational units and are difficult to capture through large-scale comparative studies [6,54]. Bronx Community College (BCC) was selected because multiple sustainability initiatives operate across curricular and co-curricular spaces alongside workforce-oriented demands, with the Associate of Applied Science (AAS) in Entrepreneurship and Small Business Management (ESBM) serving as a formal reference point. Data collection draws on qualitative documentation and interpretive analysis of institutional materials, program artifacts, and observed practices related to sustainability education at BCC.

### 4.1. Institutional Scope and Data Sources

The empirical scope of the study encompasses sustainability-related initiatives at BCC that vary in formality, institutional location, and degree of integration. Data sources include institutional documents (course syllabi, curriculum outlines, and program proposals), records from co-curricular

sustainability seminars and workshops, student artifacts from experiential learning projects, attendance and participation data from sustainability-related events, and direct observation of instructional and programmatic practices.

Together, these materials document how sustainability education is enacted across curricular, co-curricular, and programmatic spaces and how these activities are positioned within the college's broader mission.

#### 4.2. Program-Level Focus: AAS in Entrepreneurship and Small Business Management

Within the broader institutional landscape, the AAS program in ESBM is treated as a distinct unit of analysis due to its formal, credit-bearing structure. Unlike individual courses or grant-funded initiatives, the AAS represents a stable, program-level curricular configuration that enables examination of sequencing, pathway design, and institutional integration of sustainability-related content across curricular and experiential components.

The ESBM program was developed in response to local workforce, entrepreneurship, and economic development priorities in the Bronx. Although not positioned as a sustainability degree, the program incorporates sustainability-oriented practices, experiential learning, and community-engaged entrepreneurship within a structured degree pathway.

This makes the ESBM program analytically useful for examining how sustainability-related concepts and practices appear within formal curricular design alongside parallel co-curricular initiatives in a decentralized community college context.

#### 4.3. Analytic Approach

Data were analyzed using an interpretive qualitative approach focused on identifying patterns in institutional structure, curricular design, and pedagogical intent. The analysis examined how sustainability initiatives are distributed across curricular, co-curricular, and programmatic spaces, the extent to which initiatives operate in parallel or intersect, and how formal curricular structures relate to broader institutional activity.

Analytic attention focused on how learning experiences are organized across curricular and co-curricular spaces, including sequencing and institutional positioning over time. This approach aligns with scholarship framing sustainability implementation as an institutional design challenge rather than a discrete instructional intervention [67]. Table 2 summarizes the core components examined and their analytic roles, providing the empirical basis for the case analysis in Section 5.

**Table 2.** Core Case Study Components and Their Analytic Role.

Case Study Component	Core Principle / Description	Role in the Case Study Analysis
Experiential learning using Life Cycle Assessment	Structured method for analyzing environmental impacts across product's life cycle.	Examined as a curricular mechanism introducing systems thinking, trade-off analysis, and sustainability reasoning.
Seminar series perspective: Climate Science in Practice	Interdisciplinary seminars and workshops integrating scientific, policy, and applied perspectives.	Examined as a co-curricular structure situating climate knowledge in real-world contexts.
Broader sustainability, climate, and global learning initiatives	Institution-wide and grant-supported initiatives on stewardship, climate, and engagement.	Evidence of sustainability education across institutional spaces, showing breadth and coherence challenges.
Applied entrepreneurship infrastructure (Hatchery, Incubation Center, TechFest)	Experiential platforms for venture ideation, mentoring, project-based engagement.	Examined as applied learning environments translating sustainability ideas into entrepreneurial activity.

AAS in Entrepreneurship and Small Business Management (ESBM)	Formal, credit-bearing program integrating sustainability, entrepreneurship, digital skills, and experience.	Examined as a program-level mechanism linking sustainability coursework, applied design, and workforce practice.
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## 5. Case Study: Sustainability Education at BCC-CUNY

BCC is a two-year community college within CUNY and serves a highly diverse student population in the Bronx, New York. Designated as a Hispanic-Serving Institution (HSI), BCC supports multiple educational pathways, including workforce preparation, transfer, and continuing education. The college articulates its mission around equity, respect, and integrity, with an emphasis on applied learning and community engagement [68].

Within this context, sustainability education at BCC has developed through a distributed institutional ecosystem spanning curricular offerings, co-curricular activities, externally funded initiatives, and workforce-oriented programs across departments, centers, and partnerships. The sections that follow examine key components of this ecosystem, including interdisciplinary coursework, seminar-based learning, global engagement initiatives, applied entrepreneurship infrastructure, and program-level curricular reference points.

### 5.1. Life Cycle Assessment (LCA) as Experiential Learning

Life Cycle Assessment (LCA) is incorporated at BCC as a key experiential learning component within the interdisciplinary course *Sustainability, Energy, and the Green Economy (SEGE)*, offered through the CUNY Pathways curriculum. Developed collaboratively by faculty from Physics, Chemistry, and Biology, the course introduces sustainability concepts to non-STEM majors through applied, research-oriented activities [69].

LCA is a standardized methodology for assessing environmental impacts across a product's life cycle, from raw material extraction to end-of-life disposal. Instruction follows ISO 14040 and ISO 14044, emphasizing transparency, system boundaries, and impact interpretation [71,72]. Within SEGE, LCA provides a structured framework for analyzing environmental, social, and economic dimensions through systems thinking and data-informed analysis.

Students complete an individual LCA project on a simple consumer product (e.g., tea bags or beverage containers). Projects follow four phases—goal and scope definition, inventory development, impact assessment, and interpretation—through which students identify environmental “hotspots” and reflect on regulatory and entrepreneurial implications [72,73].

For this case study, the LCA component is examined using course documents, project guidelines, student reports and presentations, and observation of instructional practices. Results show that 90% of students completed the LCA assignment, which served as the course's final capstone [69]. These materials illustrate how LCA integrates interdisciplinary science within BCC's sustainability education landscape (Table 3).

**Table 3.** Mapping of student LCA findings (selective) to specific sustainability competencies. Note: Data derived from student discussions in the SEGE course taught at BCC. “Learning Outcomes” represent the sustainability competency demonstrated by the student's conclusion.

Project Focus – Simple Consumer Item	Student Conclusion on Product	LCA Learning Outcomes (Student Competency Developed)
Tea	Most CO <sub>2</sub> emissions occur during the use phase due to water boiling	Lifecycle hotspot analysis; recognizing the role of consumer behavior
Coffee	Over 70% of GHG emissions stem from electricity use in cafés and roasting facilities	Energy–carbon nexus; linking operational energy use to climate impacts

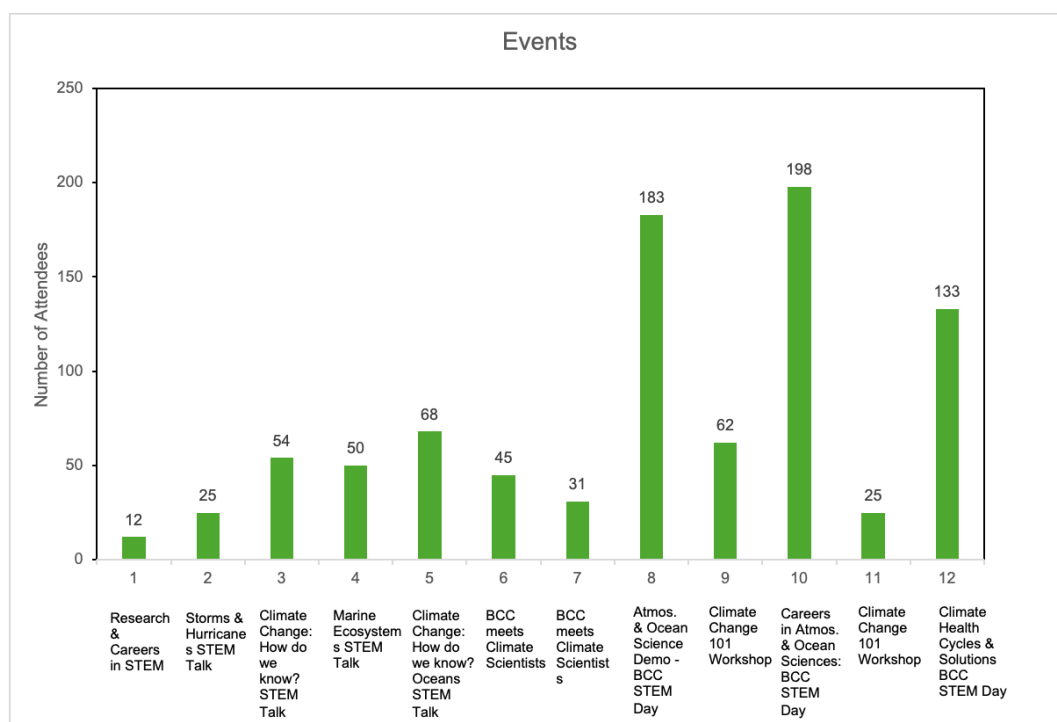
Paper Clip	A small pack of paper clips generates CO <sub>2</sub> emissions far exceeding its mass	Systems thinking; identifying hidden material intensity
Cotton T-Shirt	Only about 15% of clothing is recyclable; most ends in landfill	End-of-life and circularity; critiquing recycling versus disposal realities
Office Paper	Paper production is resource-intensive; recycling pulp poses technical and cost barriers	Technical feasibility; understanding manufacturing and economic limits
Plastic Bag	Plastic bags offer utility but pose environmental risks; recycling polyethylene can be cost-effective	Economic–environmental trade-offs; balancing cost, use, and environmental harm

### 5.2. Seminar Series Perspective: Climate Science in Practice

In addition to formal coursework, BCC offers co-curricular seminars and workshops that expose students to applied climate science and sustainability beyond the classroom. These activities serve as complementary learning spaces that engage students with external researchers and practitioners.

A central example is the BCC–CUNY Research Scholar Program (CRSP), which since 2018 has partnered with researchers from the National Oceanic and Atmospheric Administration (NOAA) and Princeton University’s Atmospheric and Oceanic Sciences group [74]. Through seminars, workshops, and hands-on events, the program introduces students—many from historically underrepresented backgrounds—to climate science topics and related career pathways.

Between 2018 and 2025, the collaboration included twelve documented events across multiple formats, reaching 886 participants (Figure 2). Over time, events shifted from introductory lectures to interactive demonstrations and large-scale STEM Day activities, with greater campus-wide integration.



**Figure 2.** Bronx Community College (BCC)-CUNY Research Scholar Program (CRSP), NOAA, and Princeton University climate science events at BCC (2018–2025). Data are derived from BCC-CUNY internal records.

### 5.3. Broader Sustainability, Climate, and Global Engagement Initiatives

Beyond formal coursework and co-curricular seminars, sustainability engagement at BCC extends across institutionally supported initiatives, grants, programs, and global learning activities (Table 4). A central example is the Bronx Green Action Challenge, a \$1 million initiative administered through the CUNY CREST Institute that supports student- and faculty-led projects focused on climate action, environmental justice, and community resilience [75,76].

Additional sustainability-related activity occurs through campus-wide conferences, Earth Day programming, climate-focused panels, and applied laboratory curricula within academic departments such as Chemistry and Chemical Technology [77–80]. At the international level, BCC incorporates sustainability themes into selected study-abroad programs, and sustainability-focused fieldwork in Spain, Australia, and India [81–84].

Sustainability-oriented workforce preparation also appears in selected applied degree programs. For example, the Automotive Technology AAS includes training related to vehicle systems, emissions, diagnostics, and emerging technologies, supported in part by external funding for workforce preparation in evolving transportation sectors [85].

Collectively, these initiatives illustrate the breadth of sustainability-related engagement at BCC while underscoring its distributed organization across programs, departments, funding streams, and institutional units.

**Table 4.** Broader Sustainability, Climate, and Global Engagement Initiatives at BCC.

Initiative / Program	Primary Focus Area	Institutional Location / Format	Sustainability Dimension
Bronx Green Action Challenge (CUNY CREST Institute)	Climate action, environmental justice, community resilience	Grant-funded, institution-wide initiative	Environmental, social
Campus conferences, Earth Day events, climate panels	Awareness, dialogue, public engagement	Co-curricular, campus-wide programming	Environmental literacy, civic engagement
Applied laboratory curricula (Chemistry, Chemical Technology)	Environmental laboratory-based learning	Departmental coursework	Technical, environmental
Study-abroad programs (Australia, India, Spain)	Ecotourism, monitoring, fieldwork	Global programs	Environmental, cultural, global
Automotive AAS	Vehicle systems, emissions, diagnostics, emerging technologies	Credit-bearing degree program	Workforce-oriented environmental transition
Automotive initiative (GM-supported)	Equipment modernization, workforce training	Externally funded program support	Applied workforce skills, sustainability
Automotive AAS	Vehicle systems, emissions, diagnostics, emerging technologies	Credit-bearing degree program	Workforce-oriented environmental transition

### 5.4. Applied Entrepreneurship Infrastructure: Hatchery, Incubation, and TechFest

BCC supports applied entrepreneurship through the STEM Entrepreneurship Hatchery and Incubation Center, established via a 2023 BCC Presidential Grant [86]. As detailed in Table 5, the Hatchery and its corresponding TechFest exhibitions operate as co-curricular, non-credit spaces independent of formal degree pathways. This structural model prioritizes applied problem-solving and professional engagement through time-bound cohorts (typically six to eight weeks).

While early cohorts were not designed as sustainability-specific, student projects frequently addressed community-relevant challenges intersecting with sustainability concerns. These included digital solutions for food waste reduction, housing access, and financial management tools for local enterprises. In 2023, the Hatchery supported two cohorts (totaling 18 students) through workshops, mentoring, and prototype development, culminating in public TechFest exhibitions.

The program is currently evolving toward an explicit focus on sustainability-oriented STEM ideas. Analytically, while these spaces foster entrepreneurship-oriented and sustainability-adjacent learning, they also illustrate the inherent limits of curricular integration when such activities remain outside formal degree programs.

**Table 5.** Structural Characteristics of the STEM Entrepreneurship Hatchery and TechFest.

<b>Dimension</b>	<b>Structural Characteristics</b>
Institutional location	Co-curricular; grant-supported
Participation basis	Voluntary; non-credit
Duration	Time-bound cohorts (approx. 6–8 weeks)
Pedagogical mode	Workshops, mentoring, prototype development, public presentation
Sustainability orientation	Indirect and project-dependent in early cohorts; explicitly sustainability-focused and STEM-oriented in later cohorts
Primary learning orientation	Applied problem-solving and professional engagement
Relationship to curriculum	Operates alongside, but outside, formal degree programs
Community orientation	Engagement with local small businesses and community-relevant challenges

##### 5.5. Program-Level Integration: The AAS in Entrepreneurship and Small Business Management

Within the broader institutional landscape, the AAS in ESBM is treated as a bounded unit of analysis because it provides a formal, credit-bearing curricular structure offered across academic years. Unlike individual courses or time-limited initiatives, the program offers a stable pathway through which sustainability-related learning can be examined across coursework and applied learning experiences.

The ESBM is a 60-credit Associate in Applied Science degree combining general education with a 39-credit major sequence in entrepreneurship, small business management, finance, marketing, and applied digital skills. Sustainability is incorporated explicitly through the required course Design for Sustainable and Green Innovations (BUS 55), which introduces principles of sustainable design, user-centered innovation, and environmentally informed product and service development. Sustainability concepts are further reinforced through applied projects, entrepreneurial problem-solving, and community-based engagements distributed across the curriculum, not as a standalone specialization.

The program's applied orientation is shaped by local economic and educational conditions in the Bronx, including high poverty rates, limited access to well-paying jobs, and lower-than-national-average educational attainment. The curriculum follows a sequenced, learning-by-doing model in which students progress from foundational business coursework to applied experiences, including cooperative work experience, internships, and micro-consulting with local enterprises. These experiential components connect classroom learning to real-world business challenges faced by Bronx-based entrepreneurs, many of whom contend with constraints related to digital access, sustainability practices, and financial management. Through structured micro-consulting and community-engaged projects, students apply entrepreneurial and sustainability-informed skills while gaining professional experience and delivering practical value to local businesses. Embedded, industry-recognized certifications further strengthen the program's workforce orientation.

As an AAS degree, the ESBM is designed primarily for direct workforce entry and entrepreneurial activity rather than as a comprehensive transfer pathway. While some courses align with CUNY-wide requirements and may be transferable on a course-by-course basis, the program's primary logic is applied skill development and local economic engagement. s summarized in Table 6, the ESBM illustrates how sustainability-informed design and entrepreneurship can be embedded within a structured programmatic framework that links workforce preparation, community

engagement, and sustainability-oriented practice, without functioning as a comprehensive institutional sustainability model.

**Table 6.** Structural Features of the AAS in Entrepreneurship and Small Business Management.

Structural Element	Program Configuration
Degree type	Associate in Applied Science (AAS)
Total credits	60
Major requirements	39 credits (entrepreneurship, small business management, finance, marketing, applied digital skills)
Sustainability placement	Explicit: BUS 55 (Design for Sustainable and Green Innovations); reinforced through projects and community engagements
Experiential components	Cooperative work experience, internships, micro-consulting with local enterprises
Transfer orientation	Course-by-course transferability; not designed as a comprehensive transfer degree
Primary program logic	Workforce preparation, entrepreneurship, and local economic development through professional support to local small businesses (e.g., micro-consulting and applied projects)

## 6. Results

This section discusses findings in relation to the study's research questions and propositions, examining sustainability education at BCC as a distributed institutional process within a decentralized governance context.

### 6.1. Governance and Context: Decentralized Conditions (RQ1 → Proposition 1)

The BCC case shows how sustainability education takes shape in a U.S. higher education context where engagement with global sustainability frameworks such as the SDGs is not nationally mandated. At BCC, sustainability-related learning is distributed across interdisciplinary coursework, co-curricular seminars, global learning initiatives, applied entrepreneurship infrastructure, and workforce-oriented academic programs rather than consolidated within a single curricular structure.

This pattern reflects conditions common to community colleges, where commitments to access and workforce preparation shape curricular priorities and resource allocation. In this context, limited discretionary resources and high instructional loads constrain comprehensive sustainability degree programs, favoring faculty-led and grant-supported initiatives that are often time-bound and organizationally discrete. The absence of national curricular coordination further reinforces localized decision-making [12,67].

Within CUNY, system-level sustainability commitments are articulated through initiatives such as Sustainable CUNY, signaling shared values while leaving implementation authority decentralized. At BCC, sustainability education is enacted through campus- and program-level initiatives aligned with local priorities rather than centralized curricular requirements. These findings support Proposition 1, indicating that in decentralized systems, institutional coherence depends on program-level structures rather than top-down mandate.

### 6.2. Institutional Integration Through Applied Pedagogies (RQ2 → Proposition 2: Institutional Integration)

Across the case, applied pedagogies play a key role in linking otherwise distributed sustainability initiatives. Activities such as Life Cycle Assessment (LCA) projects, climate science seminars, and community-engaged experiential work require students to engage with environmental, social, and economic dimensions of sustainability. This aligns with research emphasizing systems thinking and experiential learning as core to sustainability education [87–89].

The case shows that applied pedagogies occur across both curricular and co-curricular settings, with differing degrees of connection to formal program pathways. When embedded within curricula, these pedagogies recur across courses and applied experiences, allowing students to encounter sustainability-related concepts multiple times during their program. By contrast, initiatives that remain outside curricular structures tend to operate as standalone activities and depend on continued faculty or grant support for continuity.

These patterns support Proposition 2 by indicating how applied pedagogies situated within program-level structures create conditions for sustainability-related learning to accumulate over time rather than remain isolated.

### 6.3. Longitudinal Normalization Through Program-Level Pathways (RQ3 → Proposition 3)

Viewed longitudinally, sustainability education at BCC reflects gradual normalization rather than comprehensive institutional transformation. Early faculty-led initiatives created initial sites for experimentation and legitimacy, which later informed the development of more durable curricular and co-curricular structures.

Within this landscape, the AAS in ESBM functions as a program-level stabilizing pathway rather than an institutional sustainability strategy. The program provides a structured, credit-bearing context in which sustainability-related concepts, applied pedagogies, and workforce-relevant skills are encountered repeatedly by enrolled students. In this way, earlier initiatives are reinforced and sustainability-informed practices become routinized within specific educational pathways.

These feedback processes—where early initiatives inform program design and program-level outcomes reinforce institutional legitimacy—are consistent with Proposition 3. Normalization occurs through repeated practice and curricular embedding rather than formal mandate.

## 7. Conclusions

This study examined how sustainability education is enacted within a U.S. community college operating under organizational dispersion, workforce-oriented mission priorities, and limited national policy alignment with sustainability goals. Using Bronx Community College as a case, the analysis shows how sustainability-related learning develops through distributed initiatives that are selectively connected through program-level pathways and applied pedagogies, rather than through a unified or centrally coordinated institutional framework.

The significant contribution of this study is to demonstrate how program-level curricular design can function as connective infrastructure within distributed sustainability education landscapes. Rather than proposing an idealized model of institutional integration, the study shows how a formal academic program—the AAS in ESBM—can organize sustainability-related learning into a coherent pathway for students while broader institutional activity remains decentralized.

Empirically, the study situates sustainability education at the intersection of policy non-alignment in the U.S., system-level commitment exemplified through *Sustainable CUNY*, and programmatic implementation. This positioning helps explain why sustainability education in community colleges often advances incrementally rather than through comprehensive institutional transformation.

### 7.1. Implications

- For research, the findings underscore the value of process-oriented analyses of sustainability education under institutional constraint.
- For practice, the case suggests that community colleges can advance sustainability education by leveraging program-level pathways aligned with workforce and community needs.
- For policy, the study highlights the limitations of voluntary sustainability engagement and the importance of supporting durable program-level structures.

## 7.2. Future Research

Future research could extend this work through comparative community college cases, longitudinal analysis of program development, and examination of student and community outcomes associated with applied sustainability pathways in decentralized policy contexts.

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## Abbreviations

The following abbreviations are used in this manuscript: AAS—Associate in Applied Science, ESBM—Entrepreneurship and Small Business Management, LCA—Life Cycle Assessment.

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