sustainability

Article

An Exploration of the Relationship between Sustainability-Related Involvement and Learning in Higher Education

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Abstract: Higher education institutions are charged with developing civically engaged leaders to address the pressing issues facing the country and the world. While existing literature suggests institutional practices, such as promoting co-curricular involvement, hold promise for fostering key learning outcomes, educational literature suggests the benefits of participation may not be shared by all students. Using structural equation modeling, we examine the role of background characteristics (i.e., race/ethnicity and gender) and co-curricular participation in sustainability-related activities in fostering climate change leadership development and sustainability activism. We find that women reported significantly higher systems thinking, futures thinking, leadership development, and activism. Additionally, our results suggest systems thinking and futures thinking are key learning outcomes related to students' climate change leadership development and activism. Moreover, we find a small negative relationship between sustainability literacy and leadership development and activism, suggesting there might exist an inflection point at which more knowledge about climate change and sustainability issues makes students less likely to engage in leadership and activism behaviors. We discuss the implications of this work for sustainability education pedagogy in higher education.

Keywords: leadership development; activism; co-curricular involvement

1. Introduction

The National Task Force on Civic Learning and Democratic Engagement [1] lists civic engagement, social justice, community building, and diversity as several of the core common commitments for co-curricular and curricular experiences. That is, co-curricular activities—collegiate learning opportunities that happen outside of the classroom but that complement classroom instruction—are often settings in which higher education institutions develop students' citizenship in ways that challenge them to connect classroom-learned knowledge to their lives and to the world. Advancing students' citizenship through knowledge, fostering positive attitudes, engendering sustainable behaviors, and provoking social responsibility makes higher education a powerful force in driving society toward change. One goal of these educational experiences in higher education is to "empower students to become agents of positive social change in the larger society" [2] (p. 9). As such, one of the main missions of American higher education, and an expressly stated goal of the University of Michigan (the site of this study), is to educate students to become leaders in cultivating that same social change. Furthermore, calls for higher education institutions to invest in learning opportunities that support students' leadership development and civic engagement have seen steady growth over the past several decades [2]. Therefore, there is a need to assess both the efficacy of higher education curricular and co-curricular learning opportunities available to students [3,4], as well as the pathway forward for scaling these opportunities to ensure they are equitably available and beneficial to all students [5].

McAdam [6] notes that colleges and universities represent a unique opportunity to foster climate change activism given the combination of the large number of students enrolled nationwide, the potential to mobilize that large number of students in concentrated areas, and students' general availability to engage in the work of activism. In light of this, we posit that tapping into this potentially massive resource requires an understanding of the ways that climate change and sustainability knowledge, positive attitudes, and leadership behaviors develop in collegiate environments. Therefore, in the present study, we focus on sustainability education as a pathway to understanding climate change education because "on the one hand, climate change influences key natural and human living conditions and thereby also the basis for social and economic development, while on the other hand, society's priorities on sustainable development influence both the [greenhouse gas] emissions that are causing climate change and the vulnerability" [7].

The University of Michigan's sustainability efforts, including climate change education, are broad and far-reaching, including undergraduate and graduate sustainability-focused programs and courses across the entire institution as well as co-curricular sustainability learning opportunities through clubs and organizations and student life, not to mention the university's commitment to sustainability, as recently evidenced by the 2020 President's Commission on Carbon Neutrality report [8]. These efforts raise the question—to what degree are they successful in fostering key sustainability competencies and outcomes, including sustainability leadership practices? Sustainability competencies can be demarcated as knowledge, attitudes, and behaviors [3–5,9,10]. Positive environmental knowledge and attitudes have been found to impact students' pro-environmental behaviors [11–13].

In this article, we begin to explore the extent to which students' involvement in sustainability-focused co-curricular activities is related to leadership practices and other public-facing climate change and sustainability-related behaviors. Our exploratory study was guided by the following research questions:

1. What is the relationship between students' sustainability-related co-curricular involvement and key sustainability learning outcomes?
2. To what extent are demographic characteristics significant predictors of students' sustainability competencies?
3. What is the relationship between key sustainability learning outcomes and students' engagement in public sustainability-related behaviors, such as climate change leadership behaviors?

In other words, our study explored the role of participation in sustainability-related co-curricular activities in higher education in fostering key learning outcomes believed to support climate leadership practices.

2. Literature Review

In this literature review, we introduce prior scholarship on core concepts central to the present study— namely, sustainability, competencies, and involvement. Each of these concepts is deeply embedded in its own literature base and can contribute to the emerging interdisciplinary scholarship on sustainability leadership in higher education.

2.1. Sustainability

Perhaps the most widely accepted definition of sustainability comes from the Brundtland Commission's report entitled *Our Common Future*, which defines the term as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [14] (p. 1). We chose to employ this definition because it provides a broad conception of sustainability that acknowledges how inextricably linked environmental, social, and economic (in)justice are. Although sustainability has a strong focus on the natural environment (e.g., climate change, biodiversity, and water pollution), it very much also focuses on social (e.g., justice and wellness) and economic (e.g., poverty and inequality) factors, as illustrated by the Sustainable Development Goals and their indicators [15]. For example, it is well documented that minoritized communities are disproportionately affected by climate change [16] and that climate change is one of the greatest existential threats to both our environment and our world as we know it [17].

2.2. Higher Education Sustainability Education

In order to achieve a more sustainable world, higher education has a responsibility to prepare future climate change leaders, and one way to do so is by developing meaningful co-curricular learning experiences [8,14,18]. Higher education provides a rich setting to educate students about sustainability both in and out of the classroom. Formal in-class learning on sustainability includes "the process of developing students' sustainability knowledge, attitudes, and behaviors in favor of the environment, and its economic and social implications" [19–23] (p. 2). We intentionally employ this definition of sustainability education because it encompasses learning opportunities for all students (both those majoring and not majoring in sustainability-related fields). These learning opportunities may occur when students self-select sustainability-related majors or learn about sustainability in their general education and/or elective courses [23].

In addition to formal classroom learning, higher education literature (e.g., [24–26]) consistently finds that students' co-curricular learning—learning experiences outside of the classroom—is important for their overall learning. Co-curricular activities such as research experiences, living-learning communities, and service-learning are consistently found to enhance students' learning [27–29], as well as produce positive short- (e.g., academic performance, retention, degree-attainment), and long-term (e.g., graduate degree intentions, career intentions) outcomes [30,31].

In the context of sustainability learning, co-curricular experiences are valuable because they move students beyond awareness and toward engaging with environmentalism in their everyday lives [32–34]. For instance, students at hundreds of institutions are engaged in sustainability committees and actions, including advocating for socially and environmentally responsible criteria for endowments, pledging to use locally sourced food in dining halls, coordinating multi-stakeholder committees, and lobbying to create sustainability offices [34,35]. The ultimate goal of educating students about sustainability, both in and out of the classroom, is "to motivate students to become sustainably engaged citizens [20,22,36] through their commitment to environmental stewardship, and reflection about the interaction of social justice, ethics, wellbeing, and ecological and economic factors [19,37]. As such, [sustainability education] ought to guide them in connecting their learning with their future professional and personal lives in all contexts" [38] (p. 25).

2.3. Competencies

While learning goals for sustainability education have many labels [9,10], such as learning outcomes [9], capabilities [39], and competencies [40], they are primarily referred to as competencies in the higher education literature on the topic (e.g., [40,41]). A competence is "a complex combination of knowledge, skills, understanding, values, attitudes and desire which lead to effective, embodied human action in the world, in a particular domain" [11] (p. 313). As applied to the interdisciplinary field of sustainability, sustainability competencies are the specified cluster of the desired and related sustainability knowledge, skills, and attitudes that students ought to develop through higher education. To meet the desired goals of students' sustainable learning, students need to develop knowledge about the subject matter, as well as the capacity to value this knowledge and behave accordingly [4,5,12,13].

Sustainability learning, therefore, must go beyond knowledge by incorporating the attitudes and desired behaviors that support the societal transformation toward a sustainable future. Knowledge, the cognitive domain of sustainability competencies, represents the fundamental environmental, economic, and social information students ought to acquire to have a basic understanding of the concepts [42]. Failure to understand the environment and its relationship with sustainability has been correlated with negative attitudes and values and a lack of enactment of sustainable behaviors [43,44]. Attitudes represent the affective domain of sustainability learning. Many studies find that students care about the environment [45], and attitudes can support the translation of values into behaviors [5]. Behaviors represent the motor domain, within this context symbolizing informed and skills-based actions to advance sustainability [5].

In sum, the components of the three-pronged competency approach (i.e., knowledge, attitudes, and behaviors) have been shown to work in tandem, where increasing knowledge is thought to foster positive attitudes about sustainability-related issues, and increased knowledge and positive attitudes giving rise to more sustainable behaviors [40,46,47]. In other words, positive environmental knowledge and attitudes have been found to impact students' pro-environmental behaviors [48–50]. While we acknowledge existing literature that describes a gap between knowledge and pro-environmental behaviors [51], we argue it is important to study the amalgamation of all three overarching competency domains together instead of focusing solely on one of them. Throughout these overarching competency domains, more granular-level learning outcomes come to light in the literature, such as sustainability literacy [42], futures thinking [48], and environmental justice [52]. Given our focus on this granular level in the present study, we intentionally refer to these desired outcomes as *learning outcomes* instead of competencies. A list of learning outcomes elucidated by the literature base, as well as our own work described below, are defined in Table 1.

Table 1. Learning Outcomes for Sustainability Education.

Competency	Definition
Cognitive Learning Outcomes	
Sustainability Literacy	Sustainability literacy can be defined similarly to competencies, as "the knowledge, skills, and mindsets that help compel an individual to become deeply committed to building a sustainable future and allow him or her to make informed and effective decisions to this end." [53] (p. 141). It can also be understood as an outgrowth of scientific literacy whereby it is implicit concerning what students ought to know about science [54] and thus can represent what knowledge students ought to understand about sustainability.
Systems Thinking	Systems thinking represents "a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects" [55] (p.

	675). It is an interdisciplinary construct often taught in engineering [56], economics [57], and sustainability [58].
Futures Thinking	Futures thinking is "a method for informed reflection on the major changes that will occur in the next 10, 20 or more years in all areas of social life, including education. Futures Thinking uses a multidisciplinary approach to pierce the veil of received opinion and identify the dynamics that are creating the future" [59]. Given the uncertainty around climate change and sustainability, students ought to be equipped to navigate sustainability issues in this interdisciplinary way.
Contextual Competence	Contextual competence refers to the "ability to anticipate and understand the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions" [60] (p. 36). In the context of sustainability, Contextual Competence represents students' "ability to anticipate and understand the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions" within sustainability.
Affective Learning Outcomes	
Environmental Justice	Scholarship on environmental justice comes from "an interdisciplinary body of literature, in which researchers were documenting the unequal impacts of environmental pollution on different social classes and racial/ethnic groups ….. known variously as environmental racism, environmental inequality" [16]. According to the Environmental Protection Agency (EPA), environmental justice is "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies," [61].
Sense of Belonging	Sense of belonging is a college student's "perceived social support on campus, a feeling or sensation of connectedness, the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the group" [62] (p. 3). In the context of sustainability, sense of belonging is a students' perceived feeling of connectedness, mattering, acceptance within the sustainability learning space.
Behavioral Learning Outcomes	
Public Behaviors	Sustainability-related, society-oriented behaviors are often referred to as "public" behaviors. Public behaviors include collective activism in the form

	of protest/demonstration. While private behaviors are less political and reflect a form of consumer behaviors, public behaviors are more political and reflect a form of active citizenship [63,64]. Public behaviors are distinguished as visible forms of support for the environment—such as joining an environmental group or participating in a protest. Public behaviors have been understood by the literature to be the ultimate evidence of one's commitment to the environment [64].
Activism	Activism in the context of sustainability includes efforts to effect positive sustainability-related change. To be classified as activism, these efforts must extend beyond individual actions (e.g., lifestyle changes) to include collective or public behaviors. Linder et al. [65] use the term activism to broadly refer to "students' efforts to interrupt power and dominance to create more just campuses" (p. 39). Whether applicable to campus or beyond, student activism has been described as "discourse in action—a form of praxis, a profound effort toward social, economic, and political progress," [66].
Sustainability Leadership	Sustainability leadership "reflects an emerging consciousness among people who are choosing to live their lives and lead their organizations in ways that account for their impact on the earth, society, and the health of local and global economies" [46] Sustainability leaders must be able to develop a vision and being prepared to take risks all while thinking about the future [67].

3. Conceptual Framework

Research on the impact of college attendance on students' short- and long-term academic and social outcomes has received considerable scholarly attention over the past several decades. Perhaps the most often cited college impact model, one that has guided a generation of education research, is Astin's [47] input-environment-outcomes (I-E-O) college impact model.

Astin's [47] model posited that "the college can be seen as comprising three conceptually distinct components: student outputs, student inputs, and the college environment" (p. 224). Student outputs refer to the knowledge, values, beliefs, attitudes, and daily activities that colleges attempt to influence through the curricular, co-curricular, and pedagogical practices throughout students' collegiate careers. We distinguish these outcomes based on the broad categories in the sustainability competency literature (i.e., cognitive—knowledge, learning; affective—values, beliefs, attitudes; behavioral—daily activities, long-term aspirations). According to Astin's I-E-O model [47], student outcomes are the result of at least two factors—(a) inputs, such as demographic characteristics (i.e., race/ethnicity, sex), as well as prior experiences, values, dispositions, beliefs, and other factors, and (b) the college environment (e.g., collegiate learning experiences both inside and outside of the classroom, institutional policies, pedagogical practices) [47].

Over the past several decades, research on the impact of college on students has drawn attention to what Astin [47] referred to as the "interaction effect" regarding student inputs and college environments. For example, some research suggests the benefits of some learning experiences are not shared by all students due to issues of access and equity associated with particular "inputs" (e.g., racialized, gendered barriers to participation, negative perceptions of climate) [68,69]. Moreover, some practices may well *undermine* student learning due, in part, to the same issues of access to, and equity in, higher education and particular environmental factors (institutional curricular, co-curricular, and pedagogical practices). In the present study, therefore, we examine differences in sustainability-related learning outcomes by key demographic characteristics—race/ethnicity, sex, socioeconomic indicators—to address questions about the degree to which students differ in key learning outcomes resulting from participating in sustainability-related activities in college, such as living-learning communities, co-curricular activities, and internships to name a few.

Importantly, Strayhorn [70], who used Astin's I-E-O model to examine the role of practices such as faculty-student interactions, peer interactions, active learning, and institutional selectivity on personal and social development, distinguished college impact models from student development theories. Whereas "college impact models concentrate on the origins of change", Strayhorn argued, "developmental theory attempts to explain the stages through which change occurs" [70] (p. 3). This development research is chiefly interested in the role participation in sustainability-related activities plays in fostering key learning outcomes (i.e., impact). In future research, we will examine changes in these outcomes (i.e., development) that we posit result from participation in meaningful sustainability-related learning activities in higher education.

4. Materials and Methods

4.1. Site

The site for this research was U-M, a large, public, research-intensive university located in the Midwestern United States. At the time of this research study, U-M enrolled 47,907 students across the undergraduate, graduate, and professional academic levels [71]. The University is highly selective. For example, U-M cites a 3.9 average high school grade point average (GPA) for its 2019 incoming class, as well as a 97% first-year retention rate and a 92% six-year graduation rate [72].

4.2. Instrument Design

Given the many potential learning outcomes within the interdisciplinary field of sustainability, we selected several cognitive and behavioral competencies common to sustainability-related activities at the University of Michigan (U-M). To select these outcomes, we gathered an interdisciplinary team of practitioners working in units from across the U-M to report and discuss the core learning goals of their courses, programs, and activities. This team of practitioners consisted of representatives from the Graham Sustainability Institute, Student Life Sustainability, the Sustainable Living Experience, the U-M Campus Farm at the Matthaei Botanical Gardens, and Nichols Arboretum.

The **Sustainable Living Experience** is a residential learning community coordinated by the Program in the Environment, the U-M undergraduate environmental studies, and science department. **Student Life Sustainability** offers a range of co-curricular programs, academic partnerships and internships. The unit works to grow a culture of sustainability on campus among students and employees as advocates for sustainable management of energy, waste, water and infrastructure in Student Life buildings, while placing an outsized focus on the effects on people and society. The **Graham Sustainability Institute** catalyzes and facilitates sustainability-focused collaborations involving faculty, students, and external stakeholders. The Institute links knowledge to real-world impact by supporting collaborative teams spanning multiple topics, disciplines, and sectors, and the Institute views diversity, equity, and inclusion as key to empowerment and the advancement of sustainability. The **Campus Farm** at Matthaei Botanical Gardens and Nichols Arboretum is a student-driven multi-stakeholder living learning lab for sustainable food systems work built around principles of food grown by students for students, on-farm carbon-neutrality, diversity, equity, inclusion, and justice, in a learning community. Campus Farm also seeks to foster student leadership development and high-impact teaching and learning opportunities.

To develop the list of outcomes, the team first identified and described the target learning outcomes associated with their respective organizations' activities. Over a series of meetings, we synthesized key themes from a large initial list of learning outcomes and distilled the list to a final set of seven total outcomes common to the sustainability-related activities each practitioner coordinates. Moreover, we worked to establish a consistent understanding of these outcomes to ensure our measures adequately captured the goals of each activity. However, we note that while "competencies" has emerged as the predominant term within sustainability education, there is inconsistency in referring to this type of work [10]. Oftentimes, there are interchangeable labels that refer to a similar concept to sustainability competencies, such as "learning outcomes" [3]

The seven common core outcomes that were consistent across University of Michigan organizations and activities included (a) sustainability-related activism, (b) engagement in sustainability-related behaviors, (c) systems thinking, (d) futures thinking, (e) contextual competence, (f) climate change leadership, and (g) sustainability literacy. While we acknowledge that the core sustainability-related learning outcomes included in this study do not consist of an exhaustive list of sustainability competencies, we are confident they reflect desired learning outcomes across key U-M sustainability initiatives.

After we established the list of outcomes and their definitions, we conducted a literature review to identify existing, validated measures for each outcome. In the following sections, we describe the measures we drew on and adapted for the purpose of this study. We also describe the analytical process of establishing the efficacy of the online survey for adequately measuring each of the competencies included in this study.

4.3. Data Collection

At the beginning of the Fall 2020 semester, eligible U-M undergraduate and graduate students received an electronic Qualtrics survey invitation. Students were eligible for participation if they were enrolled in a sustainability-related course as identified by the Graham Sustainability Institute's Sustainability Courses Database [73] or if they participated in select university-sponsored sustainability-related activities as identified by the team of campus sustainability practitioners. In full, we invited 18,300 students to complete the online survey. After two follow-up emails, 4300 students responded to the survey invitation (23% response rate). After eliminating students who did not respond to all the questions in the survey, the study's remaining sample consisted of 3553 student respondents.

4.4. Measures

We chose measures consistent with Astin's [47] I-E-O model—student inputs (i.e., demographic characteristics), key collegiate experiences (i.e., participation in sustainability-related activities), and student outcomes (i.e., cognitive, behavioral, and affective outcomes) to answer our research questions. We also measured students' perspectives on environmental justice and sense of belonging as affective outcomes. Because our measures of affective outcomes exhibited low internal consistency, we ultimately did not include associated results. Moreover, we wished to focus particularly on behavioral indicators of leadership and activism rather than self-reports of one's level of leadership. In this paper, we examine the relationships between these variables to understand the role of participation in sustainability-related co-curricular activities in fostering key learning outcomes, as well as the role demographic characteristics might play in shaping students' learning through sustainability-related educational activities.

4.5. Student Inputs

Demographic Data

We analyzed select demographic characteristics from an institutional database, gathering indicators of race/ethnicity and sex as reported by U-M and matching demographic data using unique student identifiers. Race/ethnicity was coded in two ways in this study. First, to describe the demographic breakdown of the survey respondents in Table 2, we used dichotomously coded racial categories to indicate a racial identity (i.e., coded 1) and all other categories (i.e., coded 0). The label Black/African American, for example, indicated Black students (coded 1) compared to all other racial categories (i.e., White, Latino/a, Asian/Pacific Islander, and Native American/Native Alaskan).

Second, for the purpose of the analyses described below, we included an indicator for underrepresented minority (URM = 1 or non-URM = 0) students in our sample. URMs are those students who indicated Black/African American, Latino/a, Native Hawaiian, or Native American/Native Alaskan racial/ethnic identities, or two or more racial/ethnic identities with at least one of the above. Similarly, we coded sex (female = 1 or male = 0) dichotomously based on data provided by the institution. Table 2 below presents descriptive statistics of the demographic characteristics included in the study, as well as a comparison to the sampling frame and larger UM community [71]. While we also examined first-generation status in the present study. However, due to inconsistent definitions, as well as the inclusion of graduate students in the sample who were not labeled as first- or continuing generation students in the institutional database, first-generation status was removed from the study.

Table 2. Descriptive Statistics for Demographic Characteristics.

	Survey Sample N (%)	Sampling Frame N (%)	University Statistics N (%)
Sex			
Female	2786 (65.1)	9516 (52.1)	24,087 (50.3)
Male	1495 (34.9)	8764 (47.9)	23,820 (49.7)
Unknown	-	1 (0.01)	-
Race/Ethnicity			
Asian America/Pacific Islander	848 (19.8)	3560 (19.5)	6755 (14.1)
Black/African American	139 (3.3)	773 (4.2)	2079 (4.3)
Latino/a	313 (7.3)	1307 (7.3)	3258 (6.8)
Native American/Native Alaskan	7 (0.2)	31 (0.2)	81 (0.2)
White	2361 (55.2)	10,014 (54.8)	24,819 (51.8)
Other	613 (14.3)	2596 (14.2)	4235 (8.8)
URM Status	510 (11.9)	2392 (13.1)	6318 (13.2)
International Student Status	333 (7.8)	1762 (9.6)	6680 (13.9)

Notes: "Other" Students are those who indicated two or more racial identities or did not indicate a racial ethnic identity. Institutional data retrieved from publicly available enrollment reports [46,47].

4.6. Collegiate Environment Variables (Environment)

Sustainability-Related Involvement

We sought to understand whether students who participated in sustainability-related activities on campus and in the surrounding community exhibited different sustainability-related competencies. As such, we collected data on students' self-reported involvement with a series of dichotomously (i.e., Yes or No) coded questions. Specifically, using a single item, we asked students if they had been involved in sustainability-related activities during the past year (coded 1 = Yes or 0 = No). Our results indicated that approximately 27% of respondents reported participating in sustainability-related activities.

4.7. Behavioral Outcomes (Outputs)

This research examined two behavioral outcomes we hypothesized resulting from students' involvement in sustainability-related activities—climate change leadership practices and sustainability activism. More specifically, we hypothesized that students who participate in sustainability-related activities gain more than cognitive learning outcomes and are prepared to engage in public behaviors to meet sustainability goals. We consider these public behaviors key learning outcomes that should result from sustainability-related learning opportunities in higher education

4.7.1. Sustainability-Related Activism

Apart from their participation in sustainability clubs and organizations, we examined students' participation in behaviors related to sustainability issues in their respective communities, such as community organizing and lobbying community and congressional leaders. To measure the degree to which students participated in these behaviors, we adapted a survey instrument developed by Shephard et al. [74]. We asked students to self-report the likelihood they would participate in behaviors such as contacting local government entities and community organizing (1 = extremely unlikely, 2 = somewhat unlikely, 3 = neither likely nor unlikely, 4 = somewhat likely, and 5 = extremely likely). Cronbach's alpha for the Sustainability-related Activism scale was 0.90, indicating excellent internal consistency. Descriptive statistics for items measuring sustainability-related activism can be found in Table 3 below.

Table 3. Descriptive Statistics for Item Responses—Climate and Sustainability -Related Activism.

Item	Mean	Std. Dev.
Organize a local group to pass out leaflets to inform the public about sustainability issues in your community.	3.41	1.14
Organize a local group of people who want to increase awareness about climate change.	3.28	1.16
Organize a local group who are concerned about climate change and connect with other organizations.	3.24	1.18
Contact your local government about climate-related concerns.	3.16	1.20

4.7.2. Climate Change Leadership Practices

Additionally, a central desired learning outcome of many collegiate sustainability-related co-curricular activities is climate change leadership practices. To measure such practices, we adapted the College Student Leadership Engagement in Advocacy (CS-LEAD) instrument developed by Cadenas and Bernstein [75]. We asked students how often they engaged in sociopolitical advocacy behaviors, such as teaching new concepts about climate change to others and using networks for addressing climate change. Sustainability Leadership Development was measured on a five-point Likert scale (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, and 5 = Always). Cronbach's alpha for the Sustainability Leadership Practices scale was 0.92, indicating excellent internal consistency. Descriptive statistics for items measuring climate change leadership practices can be found in Table 4 below.

Table 4. Descriptive Statistics for Item Responses—Climate Change Leadership Practices.

Item	Mean	Std. Dev.
Persuade others to take action to help mitigate climate change.	2.93	1.16
Teach new concepts about climate change to others.	2.61	1.22
Take a role within a team addressing climate change in our work.	2.31	1.18
Establish and use networks in a community for addressing climate change.	2.22	1.13
Create innovative solutions for mitigating climate change.	2.05	1.08
Give a presentation about climate change.	1.96	1.05
Organize a project, event, etc. related to climate change initiatives.	1.94	1.00
Attend leadership training to develop skills for addressing climate change.	1.88	1.09

4.8. Cognitive Learning Outcomes (Outputs)

While behavioral outcomes measured the frequency with which students enacted sustainability-related behaviors in their lives, we were also interested in a set of cognitive learning outcomes expected to be associated with participation in sustainability-related activities in higher education. These cognitive learning outcomes included learning outcomes identified by the Practitioner Team as key goals of their respective organizations and activities. These cognitive learning outcomes included (a) systems thinking, (b) futures thinking, (c) contextual competence, and (d) sustainability literacy.

4.8.1. Systems Thinking

To measure *systems thinking*, we adapted a survey instrument developed by Hadgraft et al. [76]. Because Hadgraft and colleagues' survey was developed to assess systems thinking in engineering contexts, we adapted the survey to reflect sustainability-related educational settings. Students were asked to self-report how well they had learned about a set of systems thinking skills, such as using a holistic approach to developing sustainable solutions and managing sustainability projects, on a five-point scale (i.e., 1 = Not Well, 2 = Somewhat Well, 3 = Moderately Well, 4 = Well, and 5 = Very Well). Exploratory factor analysis of the systems thinking instrument indicated a two-factor structure—Factor A and Factor B. Cronbach's alpha for Factor A and Factor B were 0.84 and 0.87, respectively, indicating good internal consistency. Descriptive statistics for items measuring systems thinking can be found in Table 5 below.

Table 5. Descriptive Statistics for Item Responses—Systems Thinking.

Item	Mean	Std. Dev.
Systems Thinking (Factor A)		
Designing systems and/or processes for addressing sustainability problems according to specified criteria.	3.28	1.24
Managing sustainability projects.	3.25	1.26
Documenting, analyzing and reflecting on sustainability outcomes.	3.02	1.25
Using a holistic approach for designing sustainability solutions.	3.01	1.23
Working according to the principles of sustainable development.	2.63	1.15
Systems Thinking (Factor B)		
Communicating with the wider community.	2.33	1.11
Operating professionally within a business environment.	2.21	1.20
Meeting legal, professional, and ethical responsibilities.	2.07	1.07
Communicating with others in teams.	1.74	0.89
Working with people from other disciplines and cultures.	1.73	0.91

4.8.2. Futures Thinking

We measured future thinking using an adaptation of measures developed by Tonn and MacGregor [77] for this purpose. Their measures specifically ask about factors that might impede students from thinking about their personal futures. We adapted the survey instrument to reflect the specific context of sustainability-related futures thinking and used a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Exploratory factor analysis of the Futures Thinking scale indicated a two-factor structure—Factor A and Factor B. Moreover, Cronbach's alpha for Factor A was 0.84, indicating good internal consistency. However, Cronbach's alpha for Factor B was 0.66, indicating poor internal consistency. We, therefore, did not include Factor B in subsequent analyses. Descriptive statistics for items measuring futures thinking can be found in Table 6 below.

Table 6. Descriptive Statistics for Item Responses—Futures Thinking.

Item	Mean	Std. Dev.
I spend time thinking about how climate change will affect future generations.	1.99	1.03
I spend time thinking about how climate change will affect my personal future.	1.91	1.06
Thinking about the impact of climate change solutions on future generations is interesting to me.	1.88	0.94

4.8.3. Contextual Competence

We measured contextual competence using an adaptation of the Contextual Competence in Engineering (CCE) scale developed and validated by Ro et al. [60]. Since the CCE was developed to measure competence in engineering contexts specifically, we adapted the instrument to reflect the specific context of sustainability. CCE items were measured on a five-point scale (1 = Weak/None, 2 = Fair, 3 = Good, 4 = Very Good, and 5 = Excellent). Cronbach's alpha for the adapted CCE scale was 0.88, indicating good internal consistency. Descriptive statistics for items measuring contextual competence can be found in Table 7 below.

Table 7. Descriptive Statistics for Item Responses—Contextual Competence.

Item	Mean	Std. Dev.
Ability to recognize how different contexts change a solution.	3.65	0.99
Knowledge of the connections between climate change solutions and their implications for whom it benefits.	3.30	1.07
Knowledge of contexts that might affect the solution to a climate change problem.	3.24	1.04
Ability to apply knowledge about different cultures, social values, or political systems when addressing climate change challenges.	3.03	1.07

4.8.4. Sustainability Literacy

We measured sustainability literacy using an adapted set of items developed by Braun et al. [78] to assess student learning about the topic of sustainability. Braun and colleagues [78] divided these items into three broad categories—(a) explanation, analysis, and thinking skills, (b) action, doing, and (c) short answer questions. Given the goals of this study, we adapted explanation, analysis, and thinking skills items to assess students' sustainability-related learning. While Braun and colleagues' five-point scale asked students to assess their own abilities (i.e., 0 = None, 3 = Expert, and 4 = Do not know, Not applicable), we used a 5-point scale wherein students were to assess their own sustainability-related knowledge (i.e., 1 = Strongly Disagree and 5 = Strongly Agree) with regard to a set of statements related to sustainability literacy. Exploratory factor analysis of the

Sustainability Literacy items indicated a two-factor structure—Factor A and Factor B. Cronbach's alpha for Factor A was 0.85, and Cronbach's alpha for Factor B was 0.88, indicating good internal consistency. Descriptive statistics for items measuring sustainability literacy can be found in Table 8 below.

Table 8. Descriptive Statistics for Item Responses—Sustainability Literacy.

Item	Mean	Std. Dev.
Sustainability Literacy (Factor A)		
I understand the value of scientific evidence for addressing climate change.	4.75	0.60
I understand why climate change is a critical focus of scientists, businesses, communities, and organizations.	4.65	0.66
I understand the value of local/community knowledge for addressing climate change.	4.59	0.73
I understand how climate change impacts people, the planet and our economy.	4.37	0.73
Sustainability Literacy (Factor B)		
I understand strategies for achieving sustainability.	4.16	0.85
I can explain the consequences of climate change to suit various audiences/stakeholders.	3.95	1.01
I can explain what climate change is to suit various audiences/stakeholders.	3.79	1.05
I can explain the causes of climate change to suit various audiences/stakeholders.	3.79	1.04

4.9. Analytical Procedure

Data analysis proceeded in three parts. First, we established construct validity by using structural equation modeling in the following way: We examined the loadings of measured variables on each latent construct in a measurement model. While we made several modifications (e.g., removing items) to the measures to improve model fit, details of the validation process are reserved for a study describing the development and validation of the instrument. Model fit indices establishing the validity of the instrument are presented in the results section below. We examined model fit indices for the measurement model. Because variables measuring the behavioral outcomes and sustainability learning competencies were continuous, we used the maximum likelihood with a robust standard error (MLR) estimator to fit the initial measurement model.

Next, we examined demographic differences in each of the latent constructs using a multiple indicators and multiple causes (MIMIC) model. MIMIC models are structural regression models [79] wherein latent constructs are regressed on dichotomous exogenous covariates. Specifically, we examined sex (i.e., male, female) and racial/ethnic (i.e., URM, non-URM) differences in activism, leadership development, systems thinking, futures thinking, contextual competence, and literacy using a MIMIC model. Because we were interested in whether participation in sustainability-related activities in higher education is associated with these constructs, the dichotomous participation variable was also included in the MIMIC model.

Third, we examined the relationships between sustainability learning competencies (i.e., systems thinking, futures thinking, contextual competence, sustainability literacy) and behavioral outcomes (i.e., sustainability activism and leadership development) in a structural model. The structural model included the significant group differences in activism and leadership practices established in the MIMIC models to control for significant differences by sex and URM status, as well as significant differences in patterns of involvement in sustainability-related activities.

SEM fit indices recommended for models with continuous variables include the root-mean-square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index, and the standardized root mean square residual (SRMR) [80]. In the following sections, we discuss the results from (a) the measurement model establishing construct validity, (b) the MIMIC models examining exogenous predictors, and (c) the structural model examining the relationships between the learning outcomes.

5. Results

5.1. Measurement Model

First, we observed standardized coefficients for each measured variable (i.e., the question asked in the online survey) on its respective latent construct (e.g., behavioral outcomes and sustainability learning competencies). Results indicated each measured variable significantly loaded onto its theorized latent construct, offering support for construct validity. Moreover, model fit indices indicated the hypothesized structure was a good fit for the data. Though the CFI (.93) and TLI (.92) did not meet the 0.95 cutoff suggested by Hu and Bentler [80], the RMSEA (.046) and SRMR (.054) both did (.06 and 0.08, respectively).

5.2. MIMIC Models

To answer research questions one and two, we examined racial/ethnic, sex, socioeconomic, and participatory differences in each of the latent constructs in a MIMIC model. Model fit indices for the MIMIC model indicated the model fit the data slightly better than the initial measurement model, indicating mean differences in or differential item functioning in the latent constructs. For example, there were small improvements in the incremental fit indices (CFI = 0.93, TLI = 0.92), as well as slight improvements in the absolute fit indices (SRMR = 0.051, RMSEA = 0.045).

Next, we examined standardized coefficients (β) in the MIMIC model. In MIMIC models, significant coefficients for exogenous covariates—in this case, sex, URM status, and participation—indicate latent mean differences or the potential for differential item functioning. Sex, which was coded 1 for female students and 0 for male students, was a significant predictor of sustainability activism ($\beta = 0.15$, $p < 0.001$), leadership practices ($\beta = 0.05$, $p = 0.007$), futures thinking ($\beta = 0.13$, $p < 0.001$), systems thinking Factor A ($\beta = -0.09$, $p < 0.001$), systems thinking Factor B ($\beta = 0.05$, $p = 0.005$), sustainability literacy Factor A ($\beta = 0.10$, $p < 0.001$), and sustainability literacy Factor B ($\beta = -0.06$, $p < 0.001$). Because female students were coded 1 in the analysis, positive coefficients indicate female students had higher latent mean levels of activism, leadership practices, futures thinking, systems thinking (Factor B), and sustainability literacy (Factor A). On the other hand, negative coefficients indicated that female students had lower latent mean levels of systems thinking (Factor A) and sustainability literacy (Factor B).

Additionally, URM status significantly predicted systems thinking (Factor B) ($\beta = 0.08$, $p < 0.001$), as well as contextual competence ($\beta = 0.05$, $p = 0.003$). Because underrepresented minority students were coded 1, these findings indicate URM students had higher latent mean levels on both systems thinking factors, as well as contextual competence.

Next, results indicated that involvement in sustainability-related activities was a statistically significant explanatory variable for each of the behavioral outcomes. More specifically, involvement in sustainability-related educational activities was a positive predictor of each learning outcome and behavior in the model, indicating students who reported participating in sustainability-related activities had higher latent mean systems thinking (Factor A) ($\beta = 0.29$, $p < 0.001$) and (Factor B) ($\beta = 0.15$, $p < 0.001$), futures thinking ($\beta = 0.28$, $p < 0.001$), contextual competence ($\beta = 0.22$, $p < 0.001$), and sustainability literacy (Factor A) ($\beta = 0.20$, $p < 0.001$) and (Factor B)(($\beta = 0.23$, $p < 0.001$), as well as higher latent mean activism ($\beta = 0.23$, $p < 0.001$) and leadership development ($\beta = 0.43$, $p < 0.001$). These findings support the idea that participation in sustainability-related activities in higher education fosters positive sustainability-related learning outcomes and behaviors.

Finally, we wished to determine if any items in the multi-item scales behaved differently across subgroups included in the study, an indication of differential item functioning. As a result, we examined modification indices to determine if the exogenous covariates (i.e., sex, URM status, or participation) significantly predicted any measured variable in the model. Our results indicated none of the exogenous covariates significantly predicted the measured variables. Results for the MIMIC model can be found in Table 9 below.

Table 9. Standardized Results (MIMIC Model).

Construct	Std. Estimate	Standard Error	*p*-Value
Activism			
Female	0.15	0.02	<0.001
URM	0.01	0.02	0.53
Participation	0.23	0.02	<0.001
Leadership Practices			
Female	0.05	0.02	<0.001
URM	−0.01	0.02	0.42
Participation	0.43	0.02	<0.001
Systems Thinking A			
Female	−0.09	0.02	<0.001
URM	0.03	0.02	0.06
Participation	0.29	0.02	<0.001
Systems Thinking B			
Female	0.05	0.02	0.005
URM	0.08	0.02	<0.001
Participation	0.15	0.02	<0.001
Futures Thinking			
Female	0.13	0.02	<0.001
URM	0.02	0.02	0.15
Participation	0.28	0.01	<0.001
Contextual Competence			
Female	−0.003	0.02	<0.001
URM	0.001	0.02	0.938
Participation	0.233	0.02	<0.001
Literacy A			
Female	0.10	0.02	<0.001
URM	−0.002	0.02	0.89
Participation	0.20	0.02	<0.001
Literacy B			
Female	−0.06	0.02	<0.001
URM	0.001	0.02	0.94
Participation	0.23	0.02	<0.001

5.3. Structural Model

To answer the third research question about the relationships between key learning competencies (i.e., systems thinking, futures thinking, contextual competency, and literacy), and behavioral outcomes (i.e., activism and leadership), we examined a structural model wherein the two behavioral outcomes—activism and leadership—were regressed on each of the sustainability learning outcomes. Moreover, we controlled for sex, racial/ethnic, and participation differences in the behavioral outcomes by regressing activism and leadership on exogenous sex (female = 1), URM status (URM = 1), and participation (participation in sustainability-related activities = 1) variables. Full findings can be found in Figure 1 below.

First, as with other models, we assessed the structural model by examining model fit indices. Model fit indices indicate the model was a good fit to the data. The RMSEA (.047), SRMR (.067), CFI (.922), and TLI (.914) suggested the structural model was a relatively good fit for the data.

According to Diemer and Li [81], standardized coefficients are effect size estimates, with estimates less than 0.10 considered small, larger than 0.30 considered medium, and larger than 0.50 considered large. Future thinking had a significant medium effect size on sustainability activism ($\beta = 0.41,\ p < 0.001$) and a significant small effect on leadership practices ($\beta = 0.28,\ p < 0.001$). Systems thinking (Factor A) had significant medium effect sizes on leadership practices ($\beta = 0.40,\ p < 0.001$) and activism ($\beta = 0.23,\ p < 0.001$).

Interestingly, several negative, though small, relationships were present in the model. For example, sustainability literacy (Factor A) had statistically significant small negative effects on both leadership practices ($\beta = -0.14,\ p < 0.001$) and activism ($\beta = -0.07,\ p = 0.004$). Moreover, systems thinking (Factor B) had significant small effects on leadership practices ($\beta = -0.14,\ p < 0.001$) and activism ($\beta = -0.10,\ p < 0.001$). Contextual competence ($\beta = 0.14,\ p < 0.001$) and sustainability literacy (Factor B) had small positive effects on leadership practices and no statistically significant relationship with sustainability activism.

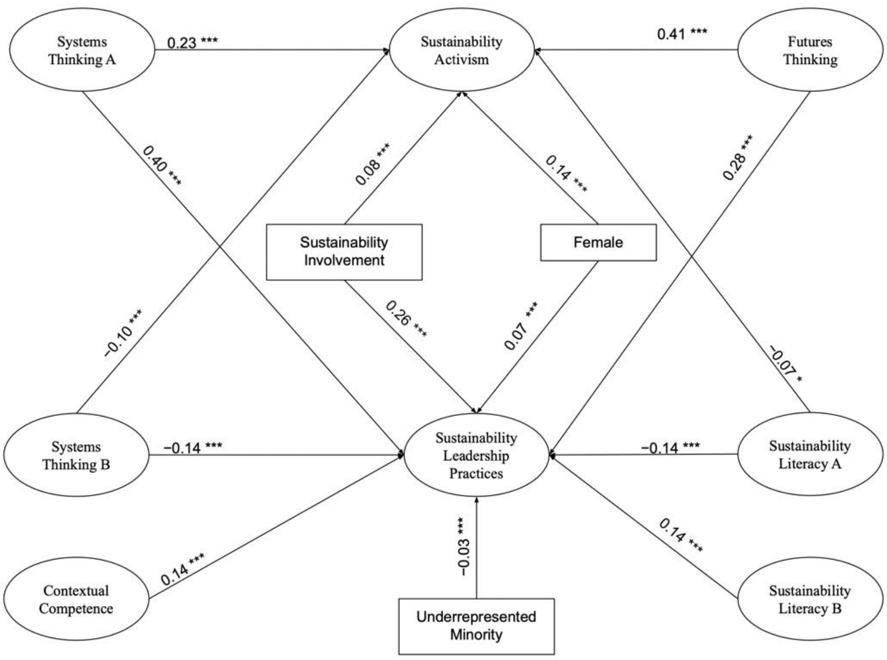

Figure 1. Structural Model. Note: *** $p < 0.001$, * $p < 0.05$.

6. Limitations

This study is limited in that it was conducted at a single institution. Moreover, we did not explore the effects of involvement in specific types of sustainability-related learning activities (e.g., sustainability living-learning communities versus sustainability-related internships) students participate in while in college. Rather, we explored the effects of involvement as opposed to non-involvement. While our findings suggest that participation in sustainability-related activities fosters key sustainability-related competencies, we can make no claims about how learning communities, for example, might foster different learning outcomes than internships or volunteer opportunities. Our future work seeks to parse the effects of different types of learning activities in higher education on these key sustainability competencies, such as leadership practices.

Moreover, our coding of demographic characteristics was also a limitation of this study. First, coding *gender* dichotomously entails an inherent erasure of trans* and non-binary students. Moreover, our use of a dichotomous variable for *underrepresented minority student* entails a problematic lumping of students across racial categories that may not capture the lived experiences of students in practice. In particular, Asian and Pacific Islander (API) students, who are not underrepresented minorities, nor are they White, do not appear separately in the MIMIC or structural models. However, this was a limitation of the institutional data we drew on in this analysis. We argue that future research should examine the role of racialized and gendered experiences in sustainability-related activities in higher education more closely to capture more depth about these students' experiences.

7. Discussion

7.1. The Role of Participation

This study examined differences in key sustainability-related learning outcomes by (a) comparing those who do and do not participate in sustainability-related activities in higher education) and (b) demographic characteristics. The first research question asked about the relationship between sustainability-related co-curricular involvement and target sustainability learning outcomes. Existing research suggests participating in meaningful learning activities fosters important cognitive and behavioral sustainability outcomes [28]. Our results support this claim, as students who reported participating in sustainability-related activities exhibited higher latent mean levels of both cognitive learning outcomes (i.e., systems and futures thinking, contextual competence, and sustainability literacy) and behavioral (i.e., activism and leadership practices).

Strayhorn [70] distinguished impact from development models—impact models seek the source of change while developmental models explain the stages through which change occurs. We, therefore, describe the conceptual model underlying this work as an impact model—our work seeks to understand the source of change. Future research will examine how the learning outcomes and behaviors we examined in this study change over time, as well as the role of curricular (i.e., coursework) and co-curricular experiences in that change. We reason that other activities that occur in sustainability-related curricular and co-curricular experiences, which we *do not* examine in this work (e.g., sustainability-related study abroad experiences), are also intricately related to the degree to which students who participate differ from those who do not. As a result, we caution the reader—while our results indicate participation might spur differences in students' learning and behaviors, not all participation entails the same activities, learning objectives, and related learning outcomes.

Kuh [28] identified 10 high-impact educational practices, of which five were examined in the present study—learning communities, collaborative projects, diversity/global learning experiences, service and community-based learning, and internships. Our future research will examine the types of sustainability-related activities (e.g., learning communities, service, community-based learning, and internships) that appear to foster sustainability activism and leadership practices. Moreover, future research might examine the types of activities typical of these high-impact practices (e.g., team-based learning, capstone projects, and service-learning) that might engender higher levels of systems and futures thinking, contextual competence, and sustainability literacy.

7.2. Demographic Differences

The second research question asked about the extent to which demographic characteristics are related to students' sustainability-related competencies. Our models detected significant gender differences in activism, leadership practices, futures thinking, systems thinking (Factor B), and sustainability literacy (Factor A), indicating female students had higher latent mean scores on these key sustainability-related learning competencies. Remington-Doucette and Musgrove explained significant gender differences in sustainability competencies by pointing to socialized gender differences, arguing, for example, that female leadership styles tend to be more participatory, democratic, compromising, considerate, and caring [82]. These styles, coupled with the overrepresentation of women in sustainability-related organizations [83], might explain the findings that women, on average, had higher latent mean scores on these key competencies.

Our models detected lower latent mean levels of systems thinking (Factor A) and sustainability literacy (Factor B) for women in the sample. We revisited the two factors to explore possible explanations for these findings. In general, items measuring systems thinking (Factor A) and sustainability literacy (Factor B) entail the public-facing sharing of information. In the previous paragraph, we describe how research suggests that women are overrepresented in the demographic makeup of environmental organizations. However, this research also suggests that women, while overrepresented in the organization, are underrepresented in leadership roles in those same organizations [84]. This might explain why women indicated higher latent mean scores on the outcomes above while scoring lower on public-facing leadership competencies. This finding suggests an important area for future research about the role gender plays in pathways to leadership in sustainability-related organizations.

Additionally, our MIMIC models detected small but statistically significant relationships between our racial/ethnic identity indicator, URM status, systems thinking, and contextual competence, indicating underrepresented minority students had higher latent mean systems thinking (i.e., both Factor A and Factor B) and contextual competence. Existing literature offers little in the way of an explanation for these findings. We suggest that thinking about complex systems be viewed as a relative strength that underrepresented students contribute to the learning environment.

7.3. Sustainability Learning Outcomes, Activism, and Leadership

Finally, we explored the relationships between the cognitive learning competencies and students' propensity to embody sustainability-related behaviors, activism, and leadership. Our results suggest the strongest relationships in the model were the positive relationships between futures thinking and systems thinking (Factor A) and the two behavioral outcomes. Surprisingly, we found a negative relationship between sustainability literacy (Factor A), which asked students about the degree to which they understood key issues related to climate change, and sustainability activism and leadership practices. In other words, students who reported higher sustainability literacy also reported lower engagement in activism and leadership practices.

Attempts to explain these findings varied. First, we wish to note that though the findings were statistically significant, the effect size between the negative relationships in the structural model was the smallest in the model. Craps [85] noted several terms—ecological grief, environmental melancholia, and ecosickness, to name a few—to describe "environmentally induced stress" associated with both physical and ecological losses (e.g., death of species) and anticipated losses associated with climate change. We suggest that this emerging line of scholarship might explain the small but significant negative relationship between literacy and activism as well as leadership. As students learn more, they might become less likely to engage in meaningful behaviors, having concluded that ecological losses are unavoidable and impossible to mitigate.

Future research might explore the relationship between ecological grief and sustainability-related behaviors, including leadership practices. If this relationship holds true, the implications for teaching and learning in sustainability-related courses and co-curricular activities are enormous. Our findings suggest, for example, that focusing on future and systems thinking might foster the leadership practices more so than focusing on sustainability literacy, including knowledge about climate change. Moreover, countering ecological grief might further enhance the positive relationships between futures as well as systems thinking and behavioral outcomes such as climate leadership practices.

7.4. Implications for Teaching about Climate Change

There are several noteworthy implications for teaching students about climate change leadership that are undergirded by the findings of our study. We begin by drawing attention to surprising negative relationships between sustainability literacy and leadership practices and activism. Though the effect sizes were small, these findings might indicate there exists an inflection point by which students might become less engaged in leadership practices as they grow in sustainability literacy. For example, as students learned more about the progress and predicted impacts of climate change, they may experience or become stuck in despair and become stifled by eco-anxiety [86,87]. This, in turn, may require explicit pedagogical tools to direct behaviors for mitigating climate change and addressing sustainability issues [88,89].

Our findings also suggest that co-curricular involvement in sustainability-related activities might augment formal classroom learning about sustainability in ways that are more likely to lead students to engage in sustainability activism and leadership. In fact, the co-curricular involvement predictor on climate change leadership practices had the largest effect size in the MIMIC model, suggesting that while the surprising finding that increased knowledge is negatively associated with climate change leadership practices, participation in meaningful sustainability-related activities can have the opposite effect on students' sustainable behaviors. This resonates with previous studies that have found that when faculty surface and engage students' prior sustainability knowledge, as learned informally out of the classroom, their formal classroom learning about sustainability increases [60,90]. It appears that leveraging students' prior knowledge, rather than working to foster new knowledge, might engender more sustainable activism and leadership.

Additionally, we found that co-curricular involvement in sustainability-related activities is related to cognitive outcomes such as futures thinking and systems thinking. Existing literature underscores futures and systems thinking as key educational outcomes of higher education, particularly as they relate to sustainability education [91]. Our results suggest students' involvement in sustainability-related co-curricular activities is positively related to their development of futures and systems thinking competencies. This might suggest that supporting involvement in sustainability-related activities is an important goal for higher education leaders seeking to foster these critical cognitive learning outcomes.

Taken collectively, we suggest further research on the differences between sustainability learning in co-curricular activities and formal learning that takes place in the classroom. In previous sections, we argued that a three-pronged approach (knowledge, attitudes, and behaviors) was necessary for supporting the University of Michigan's goals of producing climate change leaders. Specifically, we argue that while increased knowledge is thought to foster positive attitudes and, in turn, engender positive behaviors, learning related to all three in tandem, rather than any one alone, is believed to produce these positive cognitive, affective, and behavioral outcomes. Our study demonstrates that the leaders of co-curricular activities are concerned with a variety of learning outcomes apart from knowledge (i.e., literacy) alone. Conversely, it might be the case that curricular learning tends to support knowledge gains alone, without fostering a positive attitude and explicit behaviors necessary to meet institutional goals. Given the urgent climate and other sustainability challenges facing us, we suggest that instructors consider how they may not only increase students' sustainability literacy but support their leadership development.

8. Conclusions

Developing engaged sustainability and climate change leaders is a critical goal facing higher education and society; on the other hand, the higher education enterprise's role is generally seen as developing and disseminating new knowledge to its students, communities, and society broadly; our findings suggest that reaching the goal of developing sustainability and climate change leaders might entail more than developing and disseminating knowledge. Instead, educating emerging future change agents as leaders involves ensuring they have the knowledge (e.g., scientific literacy, systems, and futures thinking competencies), attitudes about sustainability issues such as environmental justice, and opportunities to engage in sustainable behaviors (e.g., activism, leadership).

Future research should explore these findings beyond the single institution (i.e., the University of Michigan) that served as the setting for this study. Moreover, we suggest that the instruments utilized in this study represent a novel approach to examining sustainability learning in higher education. Future research should also examine the efficacy of measuring student knowledge, learning, and behaviors about sustainability using survey methodologies, which might support the development of promising pedagogical practices, as well as additional research on fostering sustainability learning in higher education.

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